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Surface Preparation and Coatings

The Effectiveness of Power Tool Cleaning as an Alternative to Abrasive Blasting

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FOREWORD

This Research and Development project was performed under the National Shipbuilding Research Program (NSRP). The project is a cooperative, cost-shared effort among the Maritime Administration, the United States Navy, and National Steel and Shipbuilding Company (NASSCO). Mr. Les Hansen, NASSCO, was the Project Manager and Mr. Craig Williams, NASSCO, was the Project Engineer. Mr. John Peart, Consultant, provided technical support in the test design, evaluation, and the preparation and content of the technical report.

The objective of the National Shipbuilding Research Program is to improve productivity to reduce the cost of U.S. shipbuilding.

As NSRP Program Manager, Mr. Lynwood P. Haumschilt, NASSCO, was responsible for technical direction and publication of the final report. Program definition and guidance were provided by the members of the NSRP Technical Panel SP-3, Surface Preparation and Coatings.

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EXECUTIVE SUMMARY

The objectives of this research were (1) to review the state-of-the-art of power tool cleaning methods; (2) to evaluate the surfaces they produce and their effect upon the performance and durability of ship coating systems; and (3) to compare ship production costs using these methods with those of abrasive blasting.

The potential use of power tools in the production of the Fast Combat Support Ship (AOE-6) was studied as part of the research effort. Comparative production costs were based upon the ship's production plan. Coating performance testing was peformed using specified corrosion control systems.

The performance of three coating systems (specified for the exterior surfaces, ballast tanks, and interior spaces) was evaluated over the different surface preparation alternatives. Performance was evaluated using two aggressive salt-rich corrosion environments: (1) 2000 hours salt spray, and, (2) 29 months' marine exposure with daily wetting with saltwater. Additionally, high pressure (50 psi) salt water immersion was used to evaluate the effect of alternate coating repair surface preparation methods on the performance of a ballast tank coating.

The comparisons of coating performances over oxidized and heat darnaged shop primer prepared by the candidate cleaning methods demonstrated that the power tool cleaned (wire brush) and the Steel Structures Painting Council's, SSPC-SP-7 Brush-off blast (amended) peformed somewhat better than the SSPC-SP-1O Near white controls.

On panels where the shop primer was completely removed and the coating systems were repaired without the reapplication of the inorganic zinc primer, peformance was reduced. In this panel set, weld-and heat-affected zone repairs over SSPC-SP-1 O Near-white surface preparation were marginally better than the power tool cleaned counterparts. In the Test III subset of this preparation sequence, the ballast tank coating controIs, when exposed to a pressurized (50 psi) salt water environment, performed significantly better than the power tool cleaned counterparts.

The study reconfirned the important role of zinc rich primers, even residual shop primer, in the performance of the organic barrier coats in salt rich environments. Hence, it is important that damaged inorganic zinc primer be repaired before the application of the top coats. The Japanese use an organic zinc rich epoxy primer for this repair, but the use of an inorganic zinc may be feasible. Solvent-borne inorganic zinc applied over power tool cleaned surface is being tested at the Jacksonville, Florida exposure site.

A production cost analysis of the candidate surface preparation methods confirmed that abrasive blasting with recyclable steel abrasive is the most cost effective alternative. The use of a disposable abrasive results in a cost increase that approaches the cost of power tool cleaning. These comparisons were based upon the cost of the individual operations and did include the cost impact on other production operations. If the costs of block transport and increased coating repairs were included in the abrasive blasting cost analysis, power tool cleaning as a secondary surface preparation alternative would be economically attractive in some cases.

The modified SSPC-SP-7 Brush-off blast surface preparation method consisted of the removal of rust and brush blasting of the intact shop primer to remove the white oxidation products. The excellent performance of the coating systems applied over modified SSPC-SP-7 brush-off blast, compared with SSPC-SP-1 O Near-white, confirms the feasibility of its use rather than the SSPC-SP-10 Near-white, which is often specified. A meaningful production cost savings would be achieved without a reduction in ship coating performance or durability with the specification of this cleanliness level. A standard based upon this surface preparation should be developed and specified for preparation of the inorganic zinc shop primer.

3M coating removal ("Clean 'N Strip") discs, which performed well in the study, and vacuum recovery systems for many of the power tools are some new developments in power tool technology. These are discussed in the "Catalog of Existing Small Tools for Surface Preparation and Support Equipment for Blasters and Painters" revision which is included in this report (The original catalog was published in 1977: NSRP #0064). The use of vacuum-shrouded power tool systems may increase in ship construction because of increased environmental regulatory concerns about open abrasive blasting and capture of paint debris containing hazardous materials, e.g., lead and chromate. Suppliers and information on the recommended uses of these systems are included in the catalog update.

RESEARCH

INTRODUCTION

Zone fabrication methods implemented by U.S. shipyards, incorporating block construction and zone outfitting and painting, have increased the need for more productive methods of secondary surface preparation. This “interim product” oriented ship construction process, as implemented by the Japanese, requires automatic centrifugal wheel blasting and shop priming of steel plate and structural. Surface preparation subsequent to fabrication, outfitting and erection is restricted to power tool cleaning. Abrasive discs, wire brushes (both radial and cup), and flap abrasive discs are the most frequent secondary surface preparation methods utilized. “The effectiveness of this approach is enhanced by the selection and standardization of the coating systems specified. A National Shipbuilding Research Program study and inspection of the coating condition of Japanese ships with varying service lives verified that for many ship areas, this is a cost effective method of corrosion control.

The implementation of Japanese technology by U.S. Shipbuilding has resulted in a retention of some historical U.S. practices. In the case of surface preparation and coating, it is often a requirement that shop primers be removed by abrasive blasting to a SSPC-SP-1 O Near-white cleanliness level prior to final painting, rather than over coated as is the Japanese painting plan.

These new ship construction methods require that many areas of limited size be prepared and painted to repair damage from master butt welds and from the installation of outfitting materials by welding. Those areas requiring repainting are often in enclosed spaces near sensitive outfitting materials and equipment. The use of open abrasive blasting is not recommended due to the potential of damage to surrounding paint, outfitting items and equipment by abrasive ricochet and abrasive dust.

National Shipbuilding Research Program investigators and other researchers have found that some coatings perform well overpower tool cleaned shop primers or previously abrasive blasted and rusted steel. The performance of the coating systems over these surfaces is dependent on the severity of the exposure environment and the coating system used.

The surfaces of the construction block to be painted may be contiguous with surfaces of different ship are, e.g., freeboard, underwater hull, ballast and fuel tanks, engine room, and crew spaces. These areas are exposed to environments of varying degrees of harshness. Therefore, both surface preparation and coating requirements may vary on each block. Power tools may provide adequate surface cleanliness for the specified coating system and anticipated exposure environment for many of these surfaces.

Power tool cleaning technology has improved measurably in the past decade with the development of new tools and cleaning materials. The evaluation of these methods and their implementation as secondary surface preparation alternatives in zone construction painting offers ship construction cost savings. Their identification, evaluation, and the characterization of the paint systems and ship areas where they may be used effectively are goals of this study.

2. BACKGROUND

The application of block outfitting and painting methods to the construction of naval vessels creates some unique surface preparation and coating process problems. The high density of outfitted items, the preponderance of copper-nickel piping, and the sensitivity of much of the outfitting material associated with these ships to mechanical damage have created critical deterrents to abrasive blasting operations. Factors contributing to this are:

1. Limited access to areas to be blasted.
2. Vulnerability of outfit items to damage from abrasive ricochet.
3. Increased labor due to masking and damage control procedures.
4. Reduced blaster visibility.
5. Increased difficulty of spent abrasive removal.
6. Increasing costs and environmental impact of abrasive disposal.
7. Permanent abrasive entrapment.
8. Added man hours for damage repair.

Shipyard production planners are addressing these problems by the addition of a second outfitting operation at the “block” stage. This reduces the potential for damage, but when abrasive blasting is required, block transportation man-hours increase.

Based upon this analysis, surface preparation by abrasive blasting at the block painting stage results in increased painting and outfitting costs. Realizing this, the innovators of these production methods utilized power tool cleaning as the secondary surface preparation method of preference. Power tool cleaning after block outfitting has been used in commercial shipbuilding, but has been slow to be accepted in Naval ship construction. This is due to the rigidity of Navy specifications. This is somewhat paradoxical, since the Navy has recognized the effectiveness of power tool cleaning and the quality of the surface preparation obtained by broadly specifying its use for shipboard maintenance. NAVSEA F9040-AA-HBK-

010/FMA, Handbook of Shipboard Facilities Maintenance, provides comprehensive guidelines for the use of power tools for surface preparation prior to painting.

Prior National Shipbuilding Research Program and other studies have verified good performance of numerous coating systems over previously abrasive blasted, power tool cleaned surfaces. MIL-P-24441 and other NAVSEA approved paints have peformed well in these studies.

Many interior ship spaces, other than ballast tanks, are environmentally controlled. This provides less corrosive environments, which further supports the validity of the use of power tools. Many of these spaces require the installation of a high density of outfit items at the block stage making them ideal candidates for power tool cleaning.

3. OBJECTIVES

1. Review the state-of-the-art of the power tool cleaning technology, evaluating the quality of surface cleanliness produced and the performance of shipboard coating systems on these surfaces.

2. Identify areas of application of this technology to ship construction and determine the cost effectiveness of its use.

3. Up-date Chapter Two of the “Catalog of Existing Small Tools for Surface Preparation and Support Equipment for Blasters and Painters.”

4. STATE-OF-THE-ART

The Thomas Directory and the Journal of Protective Coatings and Linings Company Directory were used to identify suppliers of power tools, accessories and non-abrasive blast cleaning systems that may be used to remove aged coatings and corrosion products and prepare the resulting substrate for painting. A questionmaire was prepared to solicit information on the products and application methods. Response to the inquiry was limited. Telephone follow-ups resulted in additional response.

New power tool equipment and processes are discussed in detail in the Addendum C, “Catalogue of Existing Small Tools for Surface Preparation and Support Equiipment for Blasters and Painters.”

Some of the most widely used products developed since the 1977 publication of the “Small Tools Catalogue” are the attachments and heads for rotary peening equipment for both hand-held and deck machines, vacuum systems for many of the tools, and 3M coating removal (“Clean ‘N Strip”) wheels and discs.

A review of research and industry publications indicates significant activity and increased acceptance of power tool cleaning as an effective method of surface preparation for coating applications. Scarifiers to remove coatings or prepare concrete for coating in the nuclear industry, and vacuum devices to contain potentially hazardous dust and paint debris are examples of newer tools. Researchers have evaluated power tool cleaned surfaces with respect to paint performance and have found that many coatings peform surprisingly well in some of the harsh field environments.

The recognition of power tool cleaning as an acceptable method to prepare surfaces for painting is demonstrated by the issuance of NAVSEA F9040-A4-HBK-010/FMA, “Handbook of Shipboard Facilities Maintenance” and Steel Structures Painting Council’s (SSPC) Surface Preparation Specification No. 11-87T, “Power Tool Cleaning to Bare Metal.” The SSPC document covers the requirements for power tool cleaning to produce a bare metal surface and to retain or produce a surface profile.

5. POWER TOOL APPLICATION

The implementation of block planning concepts to U.S. ship construction has introduced a critical need for a productive method of surface preparation to replace abrasive blasting. A review of NASSCO’s AOE-6 production plan and paint specification confirmed this need. Power tool cleaning is the best option to fulfill this requirement.

NASSCO’S ship construction sequence is depicted in a simplified flow schematic in Figure 1.

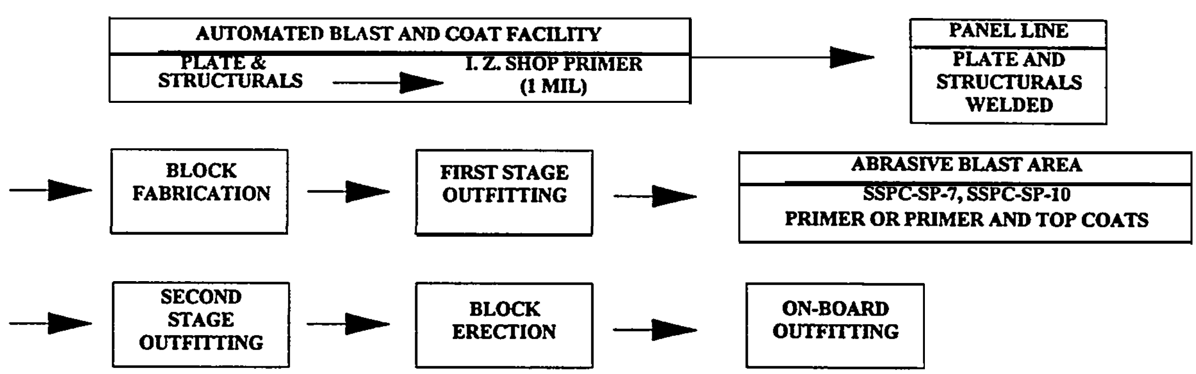

Figure 1. Production Flow Diagram

As noted by the flow diagram, the partially outfitted blocks are either brush-off blasted or cleaned to a near white metal as designated by the paint specification and based upon the location in the ship.

6. COATING PERFORMANCE TESTING

An accelerated corrosion testing program was designed and implemented to compare the performance of the coating systems specified for the Fast Combat Support Ship (AOE-6) applied over power tool cleaned substrates and SSPC-SP-1 O (Near-White Metal) control panels.

A water-based inorganic zinc shop primer (16 lb. zinc/gal.) was applied to an A-36 rolled steel sheet by NASSCO'S automated shop primer line. The facility uses six centrifugal wheels with a steel abrasive mixture consisting of S390 shot and G40 grit at a 2:1 ratio to remove mill scale and obtain a SSPC-SP-10 cleanliness level. Nominal roughness profiles of 3.7 roils, as measured by "Press-O-Film" replica tape, were obtained. An average film thickness of 1.8 roils as measured by an electromagnetic thickness gage was obtained.

Panels (4" x 6") were prepared by automatic flame cutting for a total of 124 specimens. A four-inch weld bead was deposited in the center of most panels while a 1 3/8" x 1 %" angle iron was welded to some panels. The panels were aged six weeks and sprayed daily with salt water to accelerate rusting.

In the study, coatings damaged by the welding operation and rust from exposure were removed by various surface preparation methods. Coatings applied over the various methods were evaluated with respect to performance.

A SSPC-SP-1O Near-white blast cleaning surface preparation was used as the control in all testing. SSPC-SP-7 Brush+ff blast cleaning was chosen as a test surface preparation because it is specified for the cleaning of some blocks after first stage outfitting. Coating systems were applied using conventional manual air spraying.

Figures 2 and 3 (Test Matrix I and II) summarize the surface preparation and coating systems utilized. The coating systems shown in Figure 2 (Test Matrix I) were representative of the systems specified for the exterior topside (T/S), tanks and wet spaces (W/T), and interior dry spaces (D/S). The coating systems shown in Figure 3 (Test Matrix II) were representative of tank and wet spaces specified materials.

SURFACE PREP VARIABLES	COATING SYSTEMS		
	A. TOPSIDES		
I. SP-I O: Near White (Control)	Coat # 1.	Inorganic Zinc Primer	3-5 mdft
2. SP-7: Brush-off Blast	2.	F-150 (MIL-P-24441)	2
3. POWER TOOL CLEANING i.a.w. SP-I 1-87T Abrasive flaps, 2mm needle gun, etc.	3.	F-151	3
4. POWER TOOL CLEANING Coated abrasive discs, radial wire brush, needle gun, etc.	4.	TT-E-490 (Alkyd Enamel)	1.5
	5.	TT-E-490	1.5
	B. TANKS & WETSPACES		
	Coat # 1.	International FP-034 (Epoxy)	4 mdft
	2.	International FP-052 (Epoxy)	4
	C. INTERIOR (DRY)		

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Figure 2 TEST MATRIX I

SURFACE PREP VARIABLES	COATING SYSTEMS		
INITIAL			
1. SP-10: Near White (Control)	A. MIL-P-24441 EPOXY		
2. SP-7: Brush-off Blast	Coat # 1.	F-150	3-5 mdft
FOR COATING REPAIR			
1. SP-I O: Near White			
2. Power Tool i.a.w. SP-11-87T	B. PROPRIETARY EPOXY		
3. Power Tool, other	Coat # 1.	Intl. FP-034 (Grey)	4 mdft
	2.	Intl. FP-032 (White)	4 mdft

Figure 3. TEST MATRIX II

NOTES:

1. Reference Addendum A for a detailed description of each panel set preparation and painting.
2. An additional set of Test Matrix II SSPC-SP-1O Near-white panels coated with System B was subjected to salt water pressure testing at 50 psi and at 110 °F (Test III).

All panels were knife scribed after repair. Test exposure regimens consisted of the following. (All panels were not exposed to all regimens.)

1. 2000 hours salt spray in accordance with ASTM B 117.

2. Ten and twenty nine months exposure at Ocean City Research's beach site with daily salt water wetting.

3. Salt water pressure testing at 50 psi and 110° F.

The coating performance was evaluated according to the following criteria:

1. Degree of rusting in accordance with ASTM D 610, "Evaluating the Degree of Rusting on Painted Steel Surfaces."

2. Degree of scribe undercut.

3. Degree of blistering in accordance with ASTM D 714, "Evaluating Degree of Blistering of Paints."

Performance results and test evaluations are presented in tabular form in Addendum B.

7. TEST RESULTS SUMMARY

The Test I evaluation compared the performance of the different coating systems over heat darnaged and oxidized inorganic zinc shop primer repaired using various surface preparation methods.

The Wet Space and Top Side Coating Systems performed well over power tool cleaned inorganic zinc shop primer in both 2000 hour salt spray and ten month marine exposures. Peforrnance was equal to, or-better than, SSPC-SP-1O and SSPC-SP-7 at these exposures.

Coatings applied over stainless steel wire brush cleaned surfaces peformed slightly better than other surfaces cleaned with Clean 'n Strip discs.

The SSPC-SP-7 abrasive swept shop primer performed better than the SSPC-SP-1O Near-white surfaces. This may be the result of the residual inorganic zinc shop primer providing some under-film corrosion protection.

The Interior Dry Space System performed best over wire brush preparation in both test exposures, although overall performance was only fair in salt spray-testing.

A difference in the performance of the coating systems irrespective of surface preparation was evident. The Top Side System performance was superior to the Tank Coating System in the test environments, the latter being more susceptible to undercutting at the scribe and isolated blisters. The inorganic zinc primer of the Top Side Systems reduced these defects and scribe rusting. The Dry Space System performance was good to fair in the test environments, its best performance being achieved by wire brush. The reduced performance of this system when compared to the other two systems would be expected since it was a reduced thickness Mare Island system with water-based top coats.

Performance differences due to the coating system were very pronounced after marine exposure at Sea Isle, New Jersey for twenty-nine months. The Top Side Coating's excellent performance after exposure for twenty-nine months was equivalent to its performance after ten months at the same site. The additional exposure resulted in significantly increased deterioration of the Tank Coating System. The performance of wire brush cleaning was somewhat better than the comparative surface preparation methods in these exposures.

The <u>Test II</u> evaluation compared the performance of the different coating systems after the weld damage was repaired using the comparative coating methods. The shop primer had been removed by abrasive blasting to a cleanliness grade of SSPC-SP-1 O Near-white and SSPC-SP-7 Brush-off blast before the original application of the test coating. The inorganic zinc primer was not repaired in the damaged areas before the top coats were applied; this resulted in the reduced performance of the system in this test. Aluminum oxide flap wheels/disc, Velcro pad, and zirconium disc were the power tool materials. No wire brush cleaning was performed.

The Ballast Tank System (W/S) at 2000 hours salt spray and 10 months of exposure at Sea Isle performed well with minor scribe undercutting and no blistering. Power tool cleaned panels and abrasive blasted SSPC-SP-1O controls performed similarly. One panel cleaned with a Velcro pad had a significantly larger scribe undercut of 12mrn (0.5"). After 29 months exposure at Sea Isle, the coatings degraded significantly with increased scribe undercutting, blistering in the heat affected areas, and a rust Grade of 7-8. SSPC-SP-1O cleaned repair areas performance was marginally better than the power tool cleaned panels.

The Top Side Coating System had a rust grade of 10 in both exposures with limited scribe undercutting in salt spray, but significant scribe undercutting at Sea Isle after 10 months. Significant blistering at the weld and heat affected zone was also noted in the marine exposure. The SSPC-SP-1 O cleaned surfaces were significantly better than the power tool cleaned surfaces after the 29 month marine exposure.

The single coat Mil-P-24441 Epoxy (3 roils) System (D/S) was the poorest peformer of the three systems tested. This system is specified for corrosion protection behind insulation in interior spaces. The 2000 hour salt spray exposures resulted in a rust grade of 8-10 with 5-6mm (1/4") scribe undercutting and significant blisters at the weld and heat affected zone on all panels. The power tooled panels performed measurably better than the SSPC-SP-1O controls. The majority of the D/S test panels that were to be exposed at Sea Isle, New Jersey, were lost in shipment, negating this evaluation.

There was a reduction in the performance of the Test II panels when compared to the Test I results. This reduction in performance was more obvious in the Top Side Coating System results. In the test set the shop primer was removed by abrasive blasting and the inorganic zinc primer was not repaired before top coating. The lack of residual shop primer appears to be a significant contributor in the reduction of performance. Increased scribe undercutting and blistering were the failure modes. Inorganic zinc primers typically reduce these defects in barrier coatings exposed to salt-rich environments.

Pressurized salt water immersion testing was peforrned on a Test III subset ballast tank coating. There was no blistering after fourteen days exposure. Blistering began on the scribe/weld bead side of the panels after twenty eight days exposure and increased in size and/or frequency after forty-two days. The SSPC-SP-1 O controls did not blister, except for one which had a rating of 6-8 VF (very few). The control panels performed better than the power tool cleaned panels. These Test III panels had the shop primer removed by abrasive blasting to SSPC-SP-1O Near-white before the application of the ballast coating.

COST ANALYSIS

A comparative cost analysis was performed on the various cleaning methods using industrial engineering protocols. Sanding discs, wire cup wheels, 3M coating removal (“Clean ‘N Strip”), and surface conditioning pad (“velcro”) cleaning methods were compared to abrasive blasting with recycled steel grit and disposable copper slag.

The cleaning operation time study was performed on an AOE deck assembly. Both vertical stiffeners and bulkheads were cleaned. Cleaning rates were obtained for both flat surfaces and welds. The power tools and abrasives used in the evaluation are documented in Table 1. Time study data for the study operations are presented in Table 2. The comparative cost analysis for the operations is presented in Table 3. Table 4 presents recommended power tool selection criteria for the type of surface to be cleaned and the rust condition.

TABLE 1 - POWER TOOLS AND ABRASIVE SYSTEMS

SURFACE PREPARATION ABRASIVE SYSTEMS				PNEUMATIC POWER TOOL				
MAKE	SIZE	GRADE	DESCRIPTION	MAKE	MODEL	TYPE	RPM	WT.(LBS)
ANDERSON	3/4"	.020 WIRE	WIRE END BRUSH	SUHNER	LWC-10	RT. ANGLE DIE GRINDER	10,000	2
3M	4"	X-COARSE	CLEAN'N STRIP DISC					
3M	5"	A-COARSE	VELCRO PAD					
WELLER	3"	.014 WIRE	WIRE CUP WHEEL	STANLEY	G40LA2	ANGLE SANDER	4500	4 3/8
NORTON	7"	36 GRIT	SANDING DISC					
3M	6"	X-COARSE	CLEAN'N STRIP DISC	DESCO	M225-8R	STRAIGHT AIR MOTOR	3000	4 1/2
ET ABRASIVES	3"	60 GRIT	FLAP WHEEL	STANLEY	G30LS-18	DIE GRINDER	18,000	1 3/8
VON ARX	2mm		NEEDLES	VON ARX	1-B	NEEDLE GUN	4850 BLOW/MIN	3 1/2

TABLE 2 - TIME STUDY DATA

	POWER TOOL CLEAN			BLAST	POWER TOOL CLEAN	BLAST	POWER TOOL CLEAN	BLAST
ABRASIVE TYPE	7" CLEAN 'N STRIP DISC	6" VELCRO PAD	7" SANDING DISC	SP-10	3" WIRE CUP WHEEL	SP-10	3" WIRE CUP WHEEL	SP-10
SIZE	X-COARSE	A-COARSE	36 GRIT	G-40	.014 WIRE	G-40	.014 WIRE	G-40
RPM (TOOL)	3000	10,000	4500	#7 NOZ	4500	#7 NOZ	4500	#7 NOZ
CFM (TOOL)	12	12	12	200	12	200	12	200
AREA CLEANED	OPEN SURFACE	OPEN SURFACE	OPEN SURFACE	SAME	ENCLOSED SURFACE	SAME	OPEN SURFACE WELD	SAME
TOTAL SQ FT	9	9	9	9	6.9	6.9	2.1	2.1
TIME MECH. CLEAN/BLAST	17.5 MINS	19 MINS	20 MINS	3 MINS	12 MINS	2.5MIN	5 MINS	1 MIN
CLEANUP	0	0	0	.8 MIN*	0	.7MIN*	0	.3 MIN*
TOTAL TIME	17.5 MINS	19 MINS	20 MINS	3.8MIN	12 MINS	3.2MIN	5 MINS	1.3MIN
PROFILE	1.9 MILS	1.6 MILS	1.8 MILS	3.2MIL	2.3 MILS	3.2MIL	2.3 MILS	3.2MIL

Note: Characteristics of surface prior to cleaning was aged shop primer with light to medium surface rust.
*Blast cleanup time prorated at approximately 25% of blast time.

TABLE 3 - COST ANALYSIS OF POWER TOOL CLEANING VS ABRASIVE BLASTING

COST COMPONENT PER HOUR	POWER TOOLS				ABRASIVE BLASTING SSPC-SP-10 NEAR WHITE	
	7" SANDING DISC	3" WIRE CUP WHEEL	7" CLEAN 'N STRIP DISC	6" VELCRO PAD	STEEL GRIT	COPPER SLAG
1. LABOR	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00
2. ELECTRIC	$.20	$.20	$.20	$.20	$ 5.22	$ 5.22
3. ABRASIVE/MAT.	$ 1.24	$.10	$ 1.86	$10.20	$ 7.50	$60.00
4. MAINTENANCE EQUIPMENT	$.13	$.13	$.13	$ .13	$ 1.20	$ 1.00
COMPRESSOR	$.02	$.02	$.02	$.02	$.45	$.45
5. ABRASIVE CLEAN UP/DISPOSAL					$7.08	$61.25
TOTAL COST ($/HR)	$26.59	$25.45	$27.21	$35.55	$46.45	$152.92
6. CLEANING RATE (SQ FT/HR)	27	30	32	28	135	135
COST PER SQ FT	$ .98	$.85	$ .85	$ 1.27	$.34	$ 1.13

NOTE: $$\frac{\text{COST/HR}}{\text{CLEANING(SQ FT/HR) RATE}} = \text{COST/SQ FT}$$

COSTS OF BLOCK TRANSFER FROM AND TO THE OUTFITTING AREAS TO THE ABRASIVE BLAST AREA WAS NOT INCLUDED IN THE ABRASIVE BLAST ANALYSIS.

THIS IS A COSTLY OPERATION AND ITS ELIMINATION WHEN POWER TOOL SECONDARY SURFACE PREPARATION IS USED IS A POSITIVE ECONOMIC ADVANTAGE.

Table 4. Abrasive Systems Application Areas Selection Criteria

		ABRASIVE SYSTEMS																	
		WIRE BRUSHES			SANDING DISCS					FLAPPER					CLEAN-N-STRIP WHEELS			MECHANICAL ABRATORS	
	SURFACE CONDITION	3/4"	1 1/8"	3" Cup	24	36	50	80	Velcro Pad	24 disc	36 disc	50 disc	80 disc	Wheels	3-5" dia	6-8" dia	Combo	Needle gun	Descobrader
PRIMED SURFACE	MILD SURFACE RUST																		
	WELD SEAMS																		
	Open Surface			X	X	X	X		X	X	X	X		X	X	X			
	Angles/Corners	X	X	X										X	X			X	
	PLATE SURFACE			X	X	X	X		X	X	X	X				X			X
	PIPES	X	X	X		X	X		X					X	X	X	X		
PAINTED SURFACE	HEAVY SURFACE RUST SPOTS/BLISTERS																		
	WELD SEAMS																		
	Open Surface			X	X	X			X	X	X			X	X	X		X	
	Angles/Corners	X	X	X										X	X			X	
	PLATE SURFACE			X	X	X	X		X	X	X	X				X			X
	PIPES	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X
	FEATHERING						X	X				X	X	X	X	X			
	HEATED SURFACE BURNT/BLISTERING																		
	WELD SEAMS																		
	Open Surface			X	X	X	X	X	X	X	X	X	X	X	X	X		X	
	Angles/Corners	X	X	X										X	X			X	
	PLATE SURFACE			X	X	X	X	X	X	X	X	X	X			X			X
	PIPES	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	FEATHERING						X	X				X	X	X	X	X			

8.1 ASSUMPTIONS/CALCULATIONS

The cost per square foot for each surface preparation method documented in Table 3 was based upon the. following assumptions and calculations.

In Table 3, line items 1 through 5 are cost components evaluated on a cost per hour basis. The sum of these five cost components is totaled in the row labeled "TOTAL (cost/hr)." Item number 6, labeled "Cleaning Rate (sq. ft.lhr), is the cleaning rate observed through time studies of each type of tool evaluated. The final line item, "Cost per sq. ft.", is the total cost per sq. ft. of each tool evaluated. The calculation was made by dividing the "TOTAL (cost/h.r)" row of each tool by line item 6, "Cleaning Rate (sq. ft./hr)", for each tool.

For example: 7" sanding disc operating cost/hr. is calculated as follows:

$$\frac{\$26.59/hr}{27\ sq.\ ft./hr} = \$.98/sq.\ ft.$$

The following assumptions and calculations were made in determining line items 1 through 5.

1. Labor - A rate of $25.00/hr was assumed for all operations.

2. Electricity - A cost of $.10 per kilowatt hour was used.

   Hourly Compressor Horsepower Requirements - 1 hp will generate 4.5 cu.ft./min of air at 90 psig.

   a) A blast nozzle requires 240 CFM of air -- $\frac{240\ CFM}{4.5\ CFM/hp} = 53\ hp$

   Additionally, it was assumed that an additional 1/3 of the horse power required was needed to recover the abrasive during cleanup using a vacuum recovery system, sweeper and elevator hopper.

   b) Air power tools require 12 CFM of air -- $\frac{12\ CFM}{4.5\ CFM/hp} = 2.7\ hp$

   For conversion purposes 1 hp = 745.7 watts
   Therefore 53 hp (blast nozzle) + 17 hp (1/3 of 53 for cleanup) = 70 hp
   70 hp x 745.7 watts/hp (@ 100% efficiency) = 52,199 watts or 52.2 [illegible]

This is the calculated cost per hour for electricity when blasting using steel grit or copper slag shown on chart. A similar calculation was made for the cost of electricity for the air power tools.

3. Abrasive Costs

a) Copper slag $60/ton -1 ton per hour is consumed by abrasive blasting.
b) Steel grit $500/ton - approximately 30 lbs. per hour are consumed during blasting (180 sq. ft.lhr. x 17 lbs./sq. ft. = 3,060 lbs./100 recycles =30 Ibs consumed).
Therefore, 30 lbs. x $500/2000 lbs. = $7.50.
c) Sanding discs -2 consumed per hr. ($.62/each)= $1.24.
d) Wire cup wheel - assumed life 4 hrs. x 23 days = 92 hrs.
Therefore, $9.00/wheel/92 hrs. = $.10 per hr.

Note: The 7" Clean N Strip disc and 6" Velcro pad were calculated in a similar manner. The number of discs and pads used per hour was determined from time study.

4. Equipment Maintenance

a) Slag - A $1.00 per hour cost was assumed for blast hoses, couplings and nozzles.
b) Grit - A $1.20 per hour cost was assumed with an additional $.20/hr. for vacuum recovery equipment, sweepers, and elevator hopper repair.
c) Power tools - a majority of tools used were low cost catalog purchased tools made in Taiwan. Their life expectancy was assumed to be 6 months. Therefore, assuming 4 hrs./day x 23 days/month x 6 months = 552 hrs. at a tool cost of $70.00/552 hrs. = $.13 per hr.

d) Compressor - A general rule is $.03 per 1000 cfm of air
Air tools use approximately 12 cfin or 720 cf per hr., at a cost of $.02 per hr. for these tools.
During blasting, a #7 (7/16) nozzle uses approximately 240cfin air which would equate to a cost of $.0075 per minute or about $.45 per hour of continuous usage.

5. Abrasive Cleanup/Disposal

a) Slag -1 ton per hr. usage at a disposal cost of $55 per ton
b) Steel grit -30 Ibs. per hr. at a disposal cost of $55 per ton equals $.83 per hr.

It was also assumed that every 1 hour of blasting required 15 minutes of cleanup; therefore an additional 25% labor rate or $6.25 was added to the slag and grit disposal costs.

8.2 DISCUSSION

The cost analysis reconfirmed that abrasive blasting with the use of recyclable steel grit ($0.34/sq. ft.) is the most cost effective method of surface preparation. The substitution of a copper slag disposable abrasive increases the cost substantially to $1. 13/sq. ft. Wire brush and "Clean 'N Strip" wheels were the most cost effective methods of power tool cleaning ($0.85 sq. ft.) Power tool cleaning with Velcro pads was the most expensive method primarily because of the original material and replacement costs.

The cost of transporting the blocks from stage-one outfitting back to the abrasive blast area and then to the stage-two outfitting area was not included in the abrasive blasting cost analysis. These handling operations are extremely costly, particularly for those yards whose configuration requires longer distance movement.

CONCLUSIONS

1. The corrosion control performance of the ship coating systems applied over SSPC-SP-7 (Brush-off blast) and power tool prepared inorganic zinc shop primer was as good or better than those applied over SSPC-SP-1O (Near-white). The salt-rich accelerated test environments used for comparison are very severe, the more severe environment being the marine exposure at Sea Isle, New Jersey, with daily application of seawater.

2. The candidate power tool cleaning methods left a residual surface profile of 1.5 to 2.0 roils. The original abrasive blast profile was nominally 3 roils. Contrary to the expected results, the ship coating systems applied over wire brush and SSPC-SP-7 prepared inorganic zinc shop primer performed somewhat better than when applied over the other surface preparations, including the SSPC-SP-1 O Near-white controls. This superior performance was also noted when the systems were exposed to the marine environment at Sea Isle, New Jersey, for 29 months.

3. Performance differences inherent in the coating systems tested and irrespective of surface preparation were demonstrated. The superior pefiormance of the systems that were applied over zinc, whether it was residual shop primer or the top side system, was very obvious. The coating systems without zinc tended to have increased scribe cut-back and blister initiation. This was particularly apparent in the test series where the coating systems were applied over SSPC-SP-1O (Near-white) and repaired without the reapplication of the inorganic zinc primer.

4. The ballast tank coating applied over SSPC-SP-1O preparation and the repaired weld damage exposed to high pressure salt water testing indicated significantly better performance of the SSPC-SP-1O repairs than the power tool cleaning repairs. Stainless steel wire brush preparation was not evaluated in this test set.

5. Cost analysis established that abrasive blasting with recyclable steel grit is the least costly of the surface preparation methods. Abrasive blasting with disposable copper slag abrasive was significantly higher and approached the cost of preparation with wire brush and 3M coating removal (“clean ‘n strip”) discs. With the present regulatory scrutiny of zinc as a hazardous material, disposal cost of spent abrasive may increase significantly. Power tool cleaning, which generates very little waste, should become increasingly economically attractive. Abrasive blasting with disposable abrasive can generate as much as ten pounds of waste per square foot cleaned.

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Specifications:

- ASTM TEST METHODS: B1 17, Salt Spray (Fog) Testing; D61O, Evaluating the Degree of Rusting on Painted Steel Surfaces; D714, Evaluating Degree of Blistering of Paints; D870, Testing Water Resistance of Coatings Using Water Irnmersiou D1014, Conducting Exterior Exposure Tests of Paints on Steel.
- Steel Structures Painting Council SP-3 Power Tool Cleaning.
- Steel Structures Painting Council SP-7 Brush-Off Blast Cleaning.
- Steel Structures Painting Council SP-10 Near-White Blast Cleaning.
- MIL-P-24441: Paint, Epoxy-Polyamide, General Specification for.

ADDENDUM A

Test Desire

TESTING PROCEDURES

1. Test Panel Preparation

   A. A plate 5’ x 10’ x 3/16” grade ASTM A36 was purchased and processed through NASSCO’S blast and shop primer line.

      1. Plate surface profile averaged 3.2 roils after blasting.

         a. All profile readings were taken with “Press-o-Film” replica tape, x-coarse (1.5-4.5).

         b. Five profile readings were taken on one side of plate and averaged.

      2. Plate was coated with an inorganic zinc shop primer, (16 lb./gal. zinc loading) at an average dry film thickness of 1.8 roils.

         a. All dry film thickness readings were taken with a KETT Electromagnetic Coating Thickness Tester, model LE-200.

         b. Readings were taken after plate was cut into 4“ x 6“ test panels. Five random panels were selected and five readings per panel were taken for a total of twenty-five readings.

2. General Notes (Apply to all Panel Preparations)

   A. AH panels were prepared in duplicate.

   B. Average profile readings were obtained from randomly selected panels within each surface preparation category. Five profile readings were taken on each panel side within each category.

      1. The large difference in profile measured between the front and the back of panels was due to the concentrated cleaning required on front of panel because of the damage caused by the weld bead.

   c. All coating systems were applied with a hand operated conventional air spray system.

D. Total dry film thickness (DFT) readings were taken following application of the candidate coating. Five panels were randomly selected from each paint system. Two thickness readings per each panel front and back were averaged.

E. Prior to accelerated testing, all panels were scribed from near panel center (meeting point of weld bead and substrate) diagonally to closest corner.

3. Test I [Reference Addendum B, Table 1.1.1-1.1.4]

A. Simulation of aged shop primer and rust with pipe hangers and wireway stanchions.

1. A 1 3/8" x 1 1/2" piece of angle iron, 3/16" thick and 1" in length was centered and welded perpendicular to the side of each test panel.

a. Each angle iron piece was manually welded using a 11018 electrode with one continuous bead.

2. Panels were exposed to the elements, allowed to weather and rust for approximately six weeks. Panels were sprayed three times daily, twice with fresh water and once with salt water.

3. Surface preparation:

a. Control panels received a SSPC-SP-1O (Near-white) manual blast, both front and back, producing an average profile of 2.9 roils.

b. Power tool cleaned panels were cleaned with a 3/4" braided wire end brush on the front, back and weld area of panels.

c. Power tool cleaning of the welded angle iron section was done with a needle gun using 2rnm needles.

4. Two paint systems were teste& the AOE-6 Top Side coating and Ballast Tank Coating. (See Figure 2 in Section 6).

4. Test I continued Reference Addendum B, Table 1.2.1-1.2.6]

A. Simulation of aged shop primer with weld bead.

1. A six inch long continuous weld bead was applied manually along center of panel parallel with longest side using a 11018 electrode.

2. Panels were prerusted in accordance with procedure 3.A.2.

3. Surface preparation:

   a. Six control panels received a SSPC-SP-1O (Near-white) manual abrasive blast, both front and back, producing an average profile of 3.1 roils.

   b. Six panels received a manual SSPC-SP-7 (Brush-off) abrasive blast, both front and back, producing an average profile of 3.2 mils.

   c. Six panels were power tool cleaned with a 4 inch “Clean ‘N Strip” disc, both front and back, producing an average profile of 1.4 roils on front of panel and 2.3 roils on back of panel.

   d. Six panels were power tool cleaned with a 3“ wire cup brush, both front and back, producing an average diminished profile of 2.3 roils on front of panel and 2.9 roils on back of panel.

4. Three paint systems were used (Reference Figure 2, Test Matrix I, Top Side (T/S), Dry Space (D/S) and Wet Space (W/S).

5. Test II [Reference Addendurn B, Table 2.1.1-2.1.12]

A. Simulation of repairing damaged coating from application of weld bead; initially prepared by abrasive blasting to SSPC-SP-1O (Near-white).

   1. Eighteen panels were manually blasted to SSPC-SP-1O.

   2. Three sets of panels, six panels per set were painted with three different paint systems (Figure 2- Test Matrix I, W/S, T/S and D/S).

   3. Once paint systems were cured, panels were power tool cleaned with two 6“ “Clean w Strip” discs compressed together. These discs were used in an end wheel application to strip the paint off the panels in a 1 Y2° wide section along the entire 6“ length of panel to allow for the application of a weld bead.

   4. Panels were prerusted in accordance with 3.A.2.

   5. Paint damaged by welding was repaired.

      a. Six panels were reblasted to a SSPC-SP-1O around the weld and heat affected zones on front and back of panel. These panels were the controls. Average profile reading was 2.85 roils.

b. Six panel fronts were power tool cleaned with a 3”60 grit aluminum oxide flap wheel. Average profile reading was 1.52 roils.

c. Backsides of panels (b) were power tool cleaned with a 36 grit aluminum oxide 7“ sanding disc. Panels were cleaned to remove burned and blistering paint in heat affected zones and to feather-edge the remaining coating. Average profile reading was 1.9 roils.

NOTE: Damage to coatings from welding was extensive. In most cases the entire panel was stripped to the first coat of the system.

d. Six panel fronts were cleaned with a 5“ velcro pad, A-coarse. Average profile reading was 1.6 mils.

e. Backsides of the panels (d) were power tool cleaned with a 36 grit zirconium 7“ sanding disc.

6. All eighteen panels were recoated with the original paint system with the exception of the topside (T/S) paint system. Due to the presence of some of the original paint following power tool cleaning, the inorganic zinc primer could not be reapplied as part of the topside paint system.

a. In reapplying the topside (T/S) system, MIL-P-24441 epoxy F-150 was the first coat. It was applied to the front and back of the panels including the weld and heat affected zones where the entire paint system had been removed prior to welding.

Simulation of repairing damaged coating from application of weld bead; initially abrasive blast to SSPC-SP-7 Brush-off.

1. Eighteen panels were manually blasted to a level of a SSPC-SP-7 Brush-off cleanliness level.

2. Three sets of panels, six panels per set were painted with three different paint systems (Figure 2, Test Matrix I, W/S, T/S, D/S)

3. Reference 5. A.3. procedures.

4. Reference 6. A.1. procedures.

5. Reference 5. A.5. procedures.

a. Six panels were to be brush off blasted, SSPC-SP-7, a second time to repair the damaged coating (Series S - panels). Due to the extent of the damage, it was not feasible to re-Brush-off blast and effectively repair the coating damaged without actually producing a SSPC-SP-1 O Near-white surface. Therefore, the damage was repaired by power tool cleaning with a 4 inch “Clean ‘N Strip” disc.

6. Remaining procedures from 5.A were followed.

6. Test III Reference Addendum B, Test III, Table 3.1)

A. The same procedures as in 4 were followed, except that only the W/S (AOE-6 Ballast Tank) coating system was exposed to pressurized salt water testing at 50 psi and 110° F.

ADDENDUM B

Test Results

The results of both the accelerated testing and marine exposure at Ocean City's Research exposure site at Sea Isle, New Jersey, are summarized and presented in tabular form. Exposure results are reported for 10 months and notes on those tables provide a summary of the results of 29 months exposures. See References ("Specifications") for the ASTM test methods employed.

Test I

Test I was designed to compare the performance of coatings used in different ship areas over damaged (welds, abrasion) shop primer repaired by different surface preparation methods. In all cases abrasive blasted SSPC-SP-1 O Near-white panels were used as controls. The test design is representative of painted surfaces of outfitted ship sections.

<u>Test I. Table 1: Panel Series Wet Space (W/S)</u>

All panels with welded angle

- Ship Area Tanks and Wet Spaces
- Coating: One coat each International FP-034/FP-052 (8 roils TDFT) (Figure 2, Test Matrix I-B)
- Power Tool: 3/4" End Wire Brush

1.1 <u>Exposure</u> 2000 hrs Salt Spray

Grade: Rust 9-10, Average scribe undercut 4mm (1/8"), Blister 10
Performance: very good
Power tool equivalent to SSPC-SP-1O
Power tool vs. SP-10 Rating: [1](=)

1.2 <u>Exposure</u> 10 months Sea Isle, NJ, with saltwater wetting daily

Grade: Rust 10 front/back, Scribe undercut 6.5mm (1/4"), Blister 10, one control 4F.
Rust on angle 5, power tool (0) undercut and no blisters
Performance: very good
Power tool vs SP-10 Rating: (+)

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[1]<u>Rating Legend</u>:
(=): Power tool performance equal to SP-10 controls
(+): Power tool performance better than SP-10 controls
(-): Power tool performance not as good as SP-10 controls

Test I. Table 1: Panel Series Top Side Exterior (T/S)

- Ship Area: Top SideExterior
- Coating: l.Z. Primer (3-5 MDFT); Mil-P-24441, F-150 (lMDFT); Mil-P-24441, F-150 (3 MDFT); Two coats TT-E490 (3 MDFT) (Figure 2, Test Matrix I-A)
- Power Tool: 3/4” End Wire Brush

1.3 Exposure 2000 Hrs Salt Spray

Grade: Rust 10, Scribe undercut (0), Blister 10
Performance: excellent
Power tool vs SP-10 Rating: (=)

1.4 Exposure 10 months Sea Isle, NJ

Grade: Rust 10 Front/Back, Scribe undercut (0), Blister 10
Performance: excellent
Power tool vs SP-10 Rating: (+)

Test I. Table 2: Panel Series Wet Space (W/S)

All panels with weld bead

- Ship Area Tanks and Wet Spaces
- Coating: One coat each FP-034/FP-052 (8 mils TDFT) (Figure 2, Test Matrix I-B)
- Power Tool: 4“ Clean N’ Strip Disc, 3“ Cup Wire Brush

2.1 Exposure 2000 hrs Salt Spray

Grade: Rust 9-10 front/back, Scribe undercut 4mm (1/8”), Blister 10, 4F in SP-7 heat affected zone.
Performance: good
Power tool vs SP-10 Rating: (=)

2.2 Exposure 10 months Sea Isle, NJ, with saltwater wetting daily

Grade: Rust 9-10 fronthack; Scribe undercut: SP-10, 13mm (1/2"); Clean ‘n Strip, 19mm (3/4”); Blister 4F, 6F Clean ‘N Strip
Peformance: good
Power tool vs SP-10 Rating: (-)

Test I. Table 2: Panel Series (T/S)

All panels with weld bead

- Ship Area: Top Side Exterior
- Coating: I.Z. Primer (3-5 MDFT); Mil-P-24441 (4MDFT); TT-E-490 (3MDFT) (Figure 2, Test Matrix I-A)
- Power tools: 4“ Clean ‘N Strip, 3“ wire cup brush

2.3 Exposure 2000 Hrs Salt Spray

Grade: Rust 10 front/back, Scribe undercut (0), Blister 10,SP-74F back,
Performance: excellent
Power tool vs SP-1 O Rating: (=), SP-7, SP-10 = Power tools

2.4 Exposure 10 months Sea Isle, NJ, with saltwater wetting daily

Grade: Rust 10 fionthack, scribe undercut (0), Blister 10
Performance: excellent all surface preparation
Power tools vs SP-10 Rating: (=)

Test 1. Table 2: Panel Series (D/S-A)

All panels with weld bead

- Ship Area Interior Dry Space
- Coating: Mil-P-24441 (3 MDFT), two coats water thinned enamel
- Power tools: 4“ Clean ‘N Strip, 3“ wire cup brush

2.5 Exposure 2000 Hrs Salt Spray,with saltwater wetting daily

Grade: Rust 8-10 fiontiack, scribe undercut O-6mm (0-1/4”), Blister 10- 2MD.
Performance: poor, except cup brush fair
Power tools vs SP-10 Rating: Cup brush superior(+), SP-7 - Superior (+)

2.6 Exposure 10 months Sea Isle, NJ, with saltwater wetting daily

Grade: Rust 8-10 front/back, Scribe undercut 0-13mm (1/2”), Blister 10, 6F Blisters at scribe except cupbrush
Performance: cupbrush good, rest fair
Power tools vs SP~10 Rating: Cupbrush superior (+), other surface preparation equal.

Test 11

Test II was designed to compare the peformance of the different surface preparation methods used to prepare damaged fill-coat ship systems. Full-coat systems were applied to panels in which the shop primer had been removed to cleanliness levels of SSPC-SP-1 O (Near-white) and SSPC-SP-7 (Brush-off blast). The coating system was damaged by welding and repaired by various surface preparation methods. Abrasive blasted SSPC-SP-1 O panels were used as controls.

Test II. Table 1: Panel Series Wet Spaces (W/S)

- Ship Area: Tanks and wet spaces
- Coating: one coat each FP-034/FP-052, (8 mils TDFT) (Figure 2, Test Matrix I-B)
- Power tools: aluminum oxide flap wheels - discs, zirconium disc, Velcro pad, Clean ‘N Strip

1.1, 1.2 Exposure 2000 Hrs Salt spray

Grading: Rust 10; Scribe undercut 4mm (1/8”); Blister 10
Performance - excellent for all methods
Power tools vs SP-10 Rating: (=)

1.3, 1.4 Exposure 10 months Sea Isle, NJ with salt water wetting daily

Grading: Rust 10; Scribe under cut Omm. (One Velcro pad had 13mm (%’’)); Blister 10
Peformance: good
Power tool vs SP Rating: (=) except as noted above

Test 11. Table 1: Top Side Exterior (T/S)

- Ship Area Tanks and wet spaces
- Coating: Figure 2, Test Matrix I-A
- Power tools: aluminum oxide flap wheel and discs, zirconium disc, Velcro pads, Clean ‘n’ Strip discs.

1.5, 1.6 Exposure 2000 Hours Salt Spray

Grading: Rust 10; Scribe undercut 3-7mm (1/8” - 1/4”); Blister 10 (two panels had a 2F near scribe)
Performance: fair
Power tools vs SP-10 Rating: (Nearly’)

1.7,1.8 Exposure 10 months Sea Isle, NJ, with saltwater wetting daily

Grading: Rust 10; Scribe undercut Omm - 18mm (3/4”); Blister 10- 4F
Performance: very good - fair
Power tool vs SP-1 O: (-) Ranking: SP-10 = Velcro pad> zirconium disc> aluminum oxide flap wheel .

Test IL Table 1: Interior Drv Spaces (D/S)

- Ship Area: Interior dry spaces/back of insulation
- Coating: Mare Island Epoxy, 3mils DFT
- Power tools: aluminum oxide flap wheels and discs, zirconium disc, Velcro pads, Clean ‘N Strip wheels.

1.9,1.10 Exposure 2000 Hours Salt Spray

Grading: Rust 10; Scribe undercut 6mrn (1/4”); Blistering 4D-lU, blisters occurred near weld or heat affected zone.
Peformance: good-poor, SP-1 O controls - poor
Power tools vs. SP-10 Rating: Superior (+).

1.11,1.12 Exposure 10 months Sea Isle, NJ

Samples lost in shipment except for one control and one aluminum oxide flap-wheel/disc
Performance: good
Power Tools vs. SP-10 Rating: (-)

Test 111

The objective of this test was to evaluate alternate surface preparation methods for the repair of damaged tank coating. The system consisted of a two coat system: International FP-034/FP-052 at a total dry film thickness of 8 roils. A pressurized saltwater immersion exposure was chosen since it best represents ballast tank conditions. These tests were performed by the Steel Structures Painting Council. It should be noted that much of the original paint was damaged extensively by welding. The damage was more excessive because of the limited panel size than what typically would occur in a ballast tank where the mass of the steel dissipates the heat much faster.

Test III, Table 1: Pressure immersion

All panels with weld bead

- Ship Area: Ballast tanks
- Coating: one coat each FP-034/FP-052 (TDFT 8 mils)
- Power tools: aluminum oxide flap-wheel/disc, zirconium disc, Velcro pad, Clean 'N Strip

Exposure Pressurized saltwater (50 psi) at 110 ^{0}'F graded 14,28,42 days

Rust: Grade 10 and O scribe cutback for all panels.
Blister: Grade 10 after 10 days, small blister began on front and/or back near heat affected zone on some power tool cleaned panels after 28 days, blister grew somewhat larger (maximum 4 mm after 42 days). SP-1 O: one panel had blister grade 6VF, 8VF after 42 days.
Power tools vs. SP-10 Rating: (-)

TEST I EVALUATION MATRIX
TABLE 1.1.1
(WELDED ANGLE)

TEST: ASTM B 117 SALT SPRAY TESTING

LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA

TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE**	PAINT SYS.	TOT. DFT**	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
C1	FRONT - SP-10	2.9	TANK AND WET SPACES 2 COATS EPOXY FP-034 4 MDFT FP-052 4 MDFT	11.1	10	4.5mm	10	
	BACK - SP-10	2.9		7.83	10	--	10	
C2	FRONT - SP-10	2.9		11.1	10	4mm	10	2 small rust spots on angle
	BACK - SP-10	2.9		7.83	10	--	10	
W1	FRONT - 3/4" WIRE END BRUSH *	2.4		11.1	9	3.5mm	10	1 rust spot weld undercut & top section of angle
	BACK - 3/4" WIRE END BRUSH	2.5		7.83	10	--	10	
W2	FRONT - 3/4" WIRE END BRUSH *	2.4		11.1	10	4mm	10	1 rust spot on outside angle corner
	BACK - 3/4" WIRE END BRUSH	2.5		7.83	10	--	10	

* Angle iron surface was cleaned with a 2mm needle gun.
** Mils

TEST I EVALUATION MATRIX
TABLE 1.1.2
(WELDED ANGLE)

TEST: ATMOSPHERIC EXPOSURE

LOC: OCEAN CITY RESEARCH CORP., OCEAN CITY NJ

TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE**	PAINT SYS.	TOT. DFT**	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
C1	FRONT - SP-10	2.9	TANK AND WET SPACES 2 COATS EPOXY FP-034 4 MDFT FP-052 4 MDFT	11.1	10	6.4mm	10	1 rust spot on angle, scribe partial rust
	BACK - SP-10	2.9		7.83	10	--	10	
C2	FRONT - SP-10	2.9		11.1	10	6.4mm	10	blister 4f angle & rust spots, scribe total rust
	BACK - SP-10	2.9		7.83	10	--	10	
W1	FRONT - 3/4" WIRE END BRUSH *	2.4		11.1	9	0	10	angle & scribe total rust
	BACK - 3/4" WIRE END BRUSH	2.5		7.83	10	--	10	
W2	FRONT - 3/4" WIRE END BRUSH *	2.4		11.1	10	0	10	angle & scribe total rust
	BACK - 3/4" WIRE END BRUSH	2.5		7.83	10	--	10	

* All panels rust grade 6 or less, significant scribe undercut and blistering at 29 months. Wire brush less scribe undercut. (12.8 mm) Ranking: Wire cup brush > SP-10.
** Mils

TEST I EVALUATION MATRIX
TABLE 1.1.3
(WELDED ANGLE)

TEST: ASTM B 117 SALT SPRAY TESTING

LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA

TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE **	PAINT SYS.	TOT. DFT **	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
C1	FRONT - SP-10	2.9	TOPSIDES 5 COATS I.Z.PRIMER 3-5 MDFT MARE IS. EPOXY F-150 1 MDFT F-151 3 MDFT ALKYD ENAM TT-E-490 1.5 MDFT TT-E-490 1.5 MDFT	13.0	10	0	10	scribe rust 20%
	BACK - SP-10	2.9		9.57	10	--	10	
C2	FRONT - SP-10	2.9		13.0	10	0	10	scribe rust 0%
	BACK - SP-10	2.9		9.57	10	--	10	
W1	FRONT - 3/4" WIRE END BRUSH *	2.4		13.0	10	0	10	scribe rust 0%
	BACK - 3/4" WIRE END BRUSH	2.5		9.57	10	--	10	
W2	FRONT - 3/4" WIRE END BRUSH *	2.4		13.0	10	0	10	scribe rust 0%
	BACK - 3/4" WIRE END BRUSH	2.5		9.57	10	--	10	

* Angle iron surface was cleaned with a 2mm needle gun.
** Mils

TEST I EVALUATION MATRIX
TABLE 1.1.4
(WELDED ANGLE)

TEST: ATMOSPHERIC EXPOSURE

LOC: OCEAN CITY RESEARCH CORP., OCEAN CITY NJ

TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE**	PAINT SYS.	TOT. DFT**	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
C1	FRONT - SP-10	2.9	TOPSIDES 5 COATS	13.0	10	0	10	
	BACK - SP-10	2.9	I.Z.PRIMER .3-5 MDFT	9.57	10			
C2	FRONT - SP-10	2.9	MARE IS. EPOXY	13.0	10	0	10	
	BACK - SP-10	2.9	F-150 1 MDFT	9.57	10			
W1	FRONT - 3/4" WIRE END BRUSH *	2.4	F-151 3 MDFT	13.0	10	0	10	
	BACK - 3/4" WIRE END BRUSH	·2.5	ALKYD ENAM TT-E-490	9.57	10			
W2	FRONT - 3/4" WIRE END BRUSH *	2.4	1.5 MDFT TT-E-490	13.0	10	0	10	
	BACK - 3/4" WIRE END BRUSH	2.5	1.5 MDFT	9.57	10			

* 29 month rating is identical with the ten month rating. Performance of all panels was excellent.
** Mils

TEST I EVALUATION MATRIX
TABLE 1.2.1
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING
LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA
TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
1C1	FRONT - SP-10	3.1	TANKS AND WET SPACES 2 COATS EPOXY FP-034 4 MDFT FP-052 4 MDFT	9.1	10	5mm	10	
	BACK - SP-10	3.1		8.78	10	--	10	
1C2	FRONT - SP-10	3.1		9.1	10	4mm	10	
	BACK - SP-10	3.1		8.78	10	--	10	
1S1	FRONT - SP-7	3.2		9.1	9	5mm	10	TWO RUST SPOTS ON WELD
	BACK - SP-7	3.2		8.78	10	--	4F	BLISTERS IN HEAT AFFECTED ZONE
1S2	FRONT - SP-7	3.2		9.1	9+	4.5mm	10	
	BACK - SP-7	3.2		8.78	10	--	10	
1B1	FRONT - 4" CLEAN 'N STRIP DISC	1.4		9.1	10	4mm	10	
	BACK - 4" CLEAN 'N STRIP DISC	2.3		8.78	10	--	10	
1B2	FRONT - 4" CLEAN 'N STRIP DISC	1.4		9.1	10	4mm	10	
	BACK - 4" CLEAN 'N STRIP DISC	2.3		8.78	10	--	10	
1W1	FRONT - 3" WIRE CUP BRUSH	2.3		9.1	10	3.5mm	10	
	BACK - 3" WIRE CUP BRUSH	2.9		8.78	10	--	10	
1W2	FRONT - 3" WIRE CUP BRUSH	2.3		9.1	10	4mm	10	
	BACK - 3" WIRE CUP BRUSH	2.9		8.78	10	--	10	

*Mils

TEST I EVALUATION MATRIX
TABLE 1.2.2
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE
LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, NJ
TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
1C1	FRONT - SP-10	3.1	TANKS AND WET SPACES	9.1	10	0	10	SCRIBE PARTIAL RUST
	BACK - SP-10	3.1	2 COATS	8.78	10	--	10	
1C2	FRONT - SP-10	3.1	EPOXY	9.1	10	13mm	10	SCRIBE TOTAL RUST
	BACK - SP-10	3.1	FP-034	8.78	10	--	10	
1S1	FRONT - SP-7	3.2	4 MDFT	9.1	10	0	10	SCRIBE TOTAL RUST
	BACK - SP-7	3.2	FP-052	8.78	10	--	10	
1S2	FRONT - SP-7	3.2	4 MDFT	9.1	10	0	10	SCRIBE TOTAL RUST
	BACK - SP-7	3.2		8.78	10	--	10	
1B1	FRONT - 4" CLEAN 'N STRIP DISC	1.4		9.1	10	19mm	10	SCRIBE TOTAL RUST, BLISTERS 4F
	BACK - 4" CLEAN 'N STRIP DISC	2.3		8.78	9	--	10	
1B2	FRONT - 4" CLEAN 'N STRIP DISC	1.4		9.1	10	19mm	10	SCRIBE TOTAL RUST, BLISTERS 6F
	BACK - 4" CLEAN 'N STRIP DISC	2.3		8.78	10	--	10	
1W1	FRONT - 3" WIRE CUP BRUSH	2.3		9.1	10	0	10	SCRIBE TOTAL RUST
	BACK - 3" WIRE CUP BRUSH	2.9		8.78	10	--	10	
1W2	FRONT - 3" WIRE CUP BRUSH	2.3		9.1	10	0	10	SCRIBE TOTAL RUST
	BACK - 3" WIRE CUP BRUSH	2.9		8.78	10	--	10	

Note: After 29 months of exposure, all panels had rust grade of 6 or less, excessive scribe undercut, panels blistered with the exception of those panels cleaned with a wire brush.
Ranking: Wire cup brush > SP-7 > SP-10 > Clean 'n Strip.
*Mils

TEST I EVALUATION MATRIX
TABLE 1.2.3
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING
LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA
TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
1C1	FRONT - SP-10	3.1	TOPSIDES	10	10	0	10	SCRIBE RUST 30%
	BACK - SP-10	3.1	5 COATS	9.21	10	--	10	
1C2	FRONT - SP-10	3.1	I.Z.PRIMER 3-5 MDFT	10	10	0	10	SCRIBE RUST 25%
	BACK - SP-10	3.1		9.21	10	--	10	
1S1	FRONT - SP-7	3.2	MARE IS. EPOXY	10	10	0	10	SCRIBE RUST 95%
	BACK - SP-7	3.2	F-150 1 MDFT	9.21	10	--	10	
1S2	FRONT - SP-7	3.2		10	10	0	10	NO SCRIBE RUST
	BACK - SP-7	3.2	F-151 3 MDFT	9.21	10	--	10	
1B1	FRONT - 4" CLEAN 'N STRIP DISC	1.4	ALKYD ENAM	10	10	0	10	SCRIBE RUST 100%
	BACK - 4" CLEAN 'N STRIP DISC	2.3	TT-E-490 1.5 MDFT	9.21	10	--	10	
1B2	FRONT - 4" CLEAN 'N STRIP DISC	1.4		10	10	0	10	SCRIBE RUST 30%
	BACK - 4" CLEAN 'N STRIP DISC	2.3	TT-E-490 1.5 MDFT	9.21	10	--	10	
1W1	FRONT - 3" WIRE CUP BRUSH	2.3		10	10	0	10	SCRIBE RUST 10%
	BACK - 3" WIRE CUP BRUSH	2.9		9.21	10	--	10	
1W2	FRONT - 3" WIRE CUP BRUSH	2.3		10	10	0	10	SCRIBE RUST 15%
	BACK - 3" WIRE CUP BRUSH	2.9		9.21	10	--	10	

Note: Grading of 29 month exposure identical to 10 month exposure grade.
*Mils

TEST I EVALUATION MATRIX
TABLE 1.2.4
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE
LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, N.J.
TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDER CUT	BLISTER GRADE	COMMENTS
1C1	FRONT - SP-10	3.1	TOPSIDES	10	10	0	10	NO SCRIBE RUST
	BACK - SP-10	3.1	5 COATS	9.21	10	--	10	
1C2	FRONT - SP-10	3.1	I.Z.PRIMER 3-5 MDFT	10	10	0	10	DITTO
	BACK - SP-10	3.1		9.21	10	--	10	
1S1	FRONT - SP-7	3.2	MARE IS. EPOXY	10	10	0	10	DITTO
	BACK - SP-7	3.2	F-150 1 MDFT	9.21	10	--	10	
1S2	FRONT - SP-7	3.2		10	10	0	10	DITTO
	BACK - SP-7	3.2	F-151 3 MDFT	9.21	10	--	10	
1B1	FRONT - 4" CLEAN 'N STRIP DISC	1.4	ALKYD ENAM	10	10	0	10	DITTO
	BACK - 4" CLEAN 'N STRIP DISC	2.3	TT-E-490 1.5 MDFT	9.21	10	--	10	
1B2	FRONT - 4" CLEAN 'N STRIP DISC	1.4		10	10	0	10	DITTO
	BACK - 4" CLEAN 'N STRIP DISC	2.3	TT-E-490 1.5 MDFT	9.21	10	--	10	
1W1	FRONT - 3" WIRE CUP BRUSH	2.3		10	10	0	10	DITTO
	BACK - 3" WIRE CUP BRUSH	2.9		9.21	10	--	10	
1W2	FRONT - 3" WIRE CUP BRUSH	2.3		10	10	0	10	DITTO
	BACK - 3" WIRE CUP BRUSH	2.9		9.21	10	--	10	

Note: Grading of 29 month exposure to month exposure grade. Performance of all panels excellent.
*Mils

TEST I EVALUATION MATRIX
TABLE 1.2.5
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING
LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA
TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
1C1	FRONT - SP-10	3.1	INTERIOR DRY SPACES 3 COATS MARE IS. EPOXY F-150 3 MDFT WB ENAMEL DOD-E24596 1.5 MDFT DOD-E24596 1.5 MDFT	6	8	6mm	4M	BLISTERS UNIFORM OVER PANEL
	BACK - SP-10	3.1		5.31	8	--	8D	
1C2	FRONT - SP-10	3.1		6	-	2mm	6D	RUST NOT GRADABLE DUE TO BLISTERS
	BACK - SP-10	3.1		5.31	9	--	4F	
1S1	FRONT - SP-7	3.2		6	-	6mm	8D	DITTO
	BACK - SP-7	3.2		5.31	8	--	6D	
1S2	FRONT - SP-7	3.2		6	-	4mm	6D	DITTO
	BACK - SP-7	3.2		5.31	8	--	6MD	
1B1	FRONT - 4" CLEAN 'N STRIP DISC	1.4		6	9+	1mm	4F	BLTR GRP ON LF SIDE OF PANEL TOP COAT ONLY
	BACK - 4" CLEAN 'N STRIP DISC	2.3		5.31	10	--	8F	FEW BLISTERS ON SCRIBE NEAR WELD
1B2	FRONT - 4" CLEAN 'N STRIP DISC	1.4		6	9	2mm	2MD	BLISTERS GROUPED ADJACENT TO WELD
	BACK - 4" CLEAN 'N STRIP DISC	2.3		5.31	10	--	8F	
1W1	FRONT - 3" WIRE CUP BRUSH	2.3		6	10	1mm	6MD	BLISTERS GROUPED ON SIDES OF PANEL
	BACK - 3" WIRE CUP BRUSH	2.9		5.31	10	--	8F	TOP COAT BLISTERS ONLY
1W2	FRONT - 3" WIRE CUP BRUSH	2.3		6	10	0	6F	SCRIBE RUST 10%
	BACK - 3" WIRE CUP BRUSH	2.9		5.31	10	--	10	

*Mils

TEST I EVALUATION MATRIX
TABLE 1.2.6
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE
LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, N.J.
TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
1C1	FRONT - SP-10	3.1	INTERIOR DRY SPACES 3 COATS MARE IS. EPOXY F-150 3 MDFT WB ENAMEL DOD-E24596 1.5 MDFT DOD-E24596 1.5 MDFT	6	9	0	10	SCRIBE RUST 100% BLISTER 6F
	BACK - SP-10	3.1		5.31	8	--	10	
1C2	FRONT - SP-10	3.1		6	9	0	10	DITTO
	BACK - SP-10	3.1		5.31	8	--	10	
1S1	FRONT - SP-7	3.2		6	9	0	10	DITTO
	BACK - SP-7	3.2		5.31	8	--	10	
1S2	FRONT - SP-7	3.2		6	9	0	10	DITTO
	BACK - SP-7	3.2		5.31	9	--	10	
1B1	FRONT - 4" CLEAN 'N STRIP DISC	1.4		6	9	13mm	10	DITTO
	BACK - 4" CLEAN 'N STRIP DISC	2.3		5.31	9	--	10	
1B2	FRONT - 4" CLEAN 'N STRIP DISC	1.4		6	10	3.2mm	10	SCRIBE RUST 100%
	BACK - 4" CLEAN 'N STRIP DISC	2.3		5.31	10	--	10	
1W1	FRONT - 3" WIRE CUP BRUSH	2.3		6	10	0	10	DITTO
	BACK - 3" WIRE CUP BRUSH	2.9		5.31	10	--	10	
1W2	FRONT - 3" WIRE CUP BRUSH	2.3		6	9	0	10	DITTO
	BACK - 3" WIRE CUP BRUSH	2.9		5.31	9	--	10	

Note: After 29 months of exposure, all duplicates averaged rust grade 7 or better (wire brush 8+); all panels had excessive scribe and edge cut-back except wire brush panels. Rating: Wire cup brush > SP-7 > Clean 'n Strip.
*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.1
(ORIGINAL SURFACE PREP SSPC-SP-10)
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING

LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA

TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
CC1	FRONT - SP-10	2.85	TANKS AND WET SPACES 2 COATS EPOXY FP-034 4 MDFT FP-052 4 MDFT	8.03	10	3mm	10	
	BACK - SP-10	2.85		7.87	10	--	10	
CC2	FRONT - SP-10	2.85		8.03	10	2.5mm	10	
	BACK - SP-10	2.85		7.87	10	--	10	
CD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		8.03	10	3mm	10	
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	--	10	
CD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		8.03	10	4mm	10	
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	--	10	
CT1	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	4mm	10	
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	--	10	
CT2	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	3.5mm	10	
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	--	10	

*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.2
(ORIGINAL SURFACE PREP SSPC-SP-7)
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING

LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA

TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
SC1	FRONT - SP-10	2.85	TANKS AND WET SPACES 2 COATS EPOXY FP-034 4 MDFT FP-052 4 MDFT	8.03	10	5mm	10	
	BACK - SP-10	2.85		7.87	10	--	10	
SC2	FRONT - SP-10	2.85		8.03	10	4mm	10	
	BACK - SP-10	2.85		7.87	10	--	10	
SD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		8.03	10	4mm	10	
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	--	10	
SD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		8.03	10	3mm	10	
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	--	10	
ST1	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	2mm	10	
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	--	10	
ST2	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	5mm	10	
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	--	10	

*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.3
(ORIGINAL SURFACE PREP SSPC-SP-10)
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE
LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, N.J.
TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
CC1	FRONT - SP-10	2.85	TANKS AND WET SPACES 2 COATS EPOXY FP-034 4 MDFT FP-052 4 MDFT	8.03	10	0	10	SCRIBE RUST 100%
	BACK - SP-10	2.85		7.87	10	--	10	
CC2	FRONT - SP-10	2.85		8.03	10	0	10	DITTO
	BACK - SP-10	2.85		7.87	10	--	10	
CD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		8.03	10	0	10	DITTO
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	--	10	
CD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		8.03	10	0	10	DITTO
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	--	10	
CT1	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	0	10	DITTO
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	--	10	
CT2	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	0	10	DITTO
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	--	10	

Note: After 29 months exposure all panels had scribe rust, significant cut-back and blisters. Other than weld, edges and scribe panels had rust grade 7-8. SP-10 performance was marginally better than power tool.

OTHER THAN WELD, EDGES AND

*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.4
(ORIGINAL SURFACE PREP SSPC-SP-7)
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE
LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, N.J.
TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
SC1	FRONT - SP-10	2.85	TANKS AND WET SPACES 2 COATS EPOXY FP-034 4 MDFT FP-052 4 MDFT	8.03	10	0	10	PARTIAL SCRIBE RUST
	BACK - SP-10	2.85		7.87	10	--	10	
SC2	FRONT - SP-10	2.85		8.03	10	0	10	MISSING
	BACK - SP-10	2.85		7.87	10	--	10	
SD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		8.03	10	0	10	SCRIBE RUST 100%
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	--	10	
SD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		8.03	10	0	10	MISSING
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	--	10	
ST1	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	0	10	SCRIBE RUST 100%
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	--	10	
ST2	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	13mm	10	DITTO
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	--	10	

Note: After 29 months exposure general panel condition was a 6 or less; none of the surface preparation was significantly superior.
*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.5
(ORIGINAL SURFACE PREP SSPC-SP-10)
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING

LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA

TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
CC1	FRONT - SP-10	2.85	TOPSIDES	10	10	4mm	10	
	BACK - SP-10	2.85	5 COATS	9.21	10	--	10	
CC2	FRONT - SP-10	2.85	I.Z.PRIMER 3-5 MDFT	10	10	6mm	10	
	BACK - SP-10	2.85		9.21	10	--	10	
CD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52	MARE IS. EPOXY	10	10	2mm	10	
	BACK - 7" DISC-36 GRIT A.O.	1.9	F-150 1 MDFT	9.21	10	--	10	
CD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		10	10	3mm	10	
	BACK - 7" DISC-36 GRIT A.O.	1.9	F-151 3 MDFT	9.21	10	--	10	
CT1	FRONT - 5" VELCRO PAD-A COARSE	1.6	ALKYD ENAM	10	10	5mm	10	
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9	TT-E-490 1.5 MDFT	9.21	10	--	10	
CT2	FRONT - 5" VELCRO PAD-A COARSE	1.6		10	10	5mm	10	ONE LARGE BLISTER NEAR SCRIBE ADJACENT TO WELD
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9	TT-E-490 1.5 MDFT	9.21	10	--	10	

*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.6
(ORIGINAL SURFACE PREP SSPC-SP-7)
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING

LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA

TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
SC1	FRONT - SP-10	2.85	TOPSIDES	10	10	3mm	10	
	BACK - SP-10	2.85	5 COATS	9.21	10	--	10	
SC2	FRONT - SP-10	2.85	I.Z.PRIMER 3-5 MDFT	10	10	4mm	10	
	BACK - SP-10	2.85		9.21	10	--	10	
SD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52	MARE IS. EPOXY	10	10	4mm	10	
	BACK - 7" DISC-36 GRIT A.O.	1.9	F-150 1 MDFT	9.21	10	--	10	
SD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		10	10	7mm	2F	THREE LARGE BLISTERS NEAR SCRIBE
	BACK - 7" DISC-36 GRIT A.O.	1.9	F-151 3 MDFT	9.21	10	--	10	
ST1	FRONT - 5" VELCRO PAD-A COARSE	1.6	ALKYD ENAM	10	10	4mm	10	
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9	TT-E-490 1.5 MDFT	9.21	10	--	10	
ST2	FRONT - 5" VELCRO PAD-A COARSE	1.6		10	10	5mm	10	
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9	TT-E-490 1.5 MDFT	9.21	10	--	10	

*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.7
(ORIGINAL SURFACE PREP SSPC-SP-10)
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE
LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, N.J.
TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
CC1	FRONT - SP-10	2.85	TOPSIDES	10	10	6.4mm	10	SCRIBE RUST 100%
	BACK - SP-10	2.85	5 COATS	9.21	10	--	10	
CC2	FRONT - SP-10	2.85	I.Z.PRIMER 3-5 MDFT	10	10	6.4mm	10	DITTO
	BACK - SP-10	2.85		9.21	10	--	10	
CD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52	MARE IS. EPOXY	10	10	0	6F	DITTO
	BACK - 7" DISC-36 GRIT A.O.	1.9	F-150 1 MDFT	9.21	10	--	10	
CD2	FRONT - FLAP WHEEL-60 GRIT A.O.	·1.52		10	10	13mm	6F	DITTO
	BACK - 7" DISC-36 GRIT A.O.	1.9	F-151 3 MDFT	9.21	10	--	10	
CT1	FRONT - 5" VELCRO PAD-A COARSE	1.6	ALKYD ENAM	10	10	13mm	8F	DITTO
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9	TT-E-490 1.5 MDFT	9.21	10	--	10	
CT2	FRONT - 5" VELCRO PAD-A COARSE	1.6		10	10	0	10	DITTO
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9	TT-E-490 1.5 MDFT	9.21	10	--	10	

Note: After 29 months exposure, general failure of all panels by rust, scribe cut-back, blisters and weld rust except for one velcro pad/zirconium panel.
*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.8
(ORIGINAL SURFACE PREP SSPC-SP-7)
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE
LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, N.J.
TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE *	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDERCUT	BLISTER GRADE	COMMENTS
SC1	FRONT - SP-10	2.85	TOPSIDES	10	10	0	10	NO SCRIBE RUST
	BACK - SP-10	2.85	5 COATS	9.21	10	--	10	
SC2	FRONT - SP-10	2.85	I.Z.PRIMER 3-5 MDFT	10	10	0	10	SCRIBE RUST 100%
	BACK - SP-10	2.85		9.21	10	--	10	
SD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52	MARE IS. EPOXY	10	10	19mm	4F	DITTO
	BACK - 7" DISC-36 GRIT A.O.	1.9	F-150 1 MDFT	9.21	10	--	10	
SD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		10	10	19mm	4F	DITTO
	BACK - 7" DISC-36 GRIT A.O.	1.9	F-151 3 MDFT	9.21	10	--	10	
ST1	FRONT - 5" VELCRO PAD-A COARSE	1.6	ALKYD ENAM	10	10	13mm	8F	DITTO
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9	TT-E-490 1.5 MDFT	9.21	10	--	10	
ST2	FRONT - 5" VELCRO PAD-A COARSE	1.6		10	10	0	10	DITTO
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9	TT-E-490 1.5 MDFT	9.21	10	--	10	

Note: After 29 months exposure both sets of SP-10 panels performed well; all power tool panels failed.
*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.9
(ORIGINAL SURFACE PREP SSPC-SP-10)
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING

LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA

TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDER CUT	BLISTER GRADE	COMMENTS
CC1	FRONT - SP-10	2.85	INSULATED SPACES MARE IS. EPOXY F-150 3 MDFT	3.54	9	5mm	4D	RUST AND BLISTERS AROUND WELD
	BACK - SP-10	2.85		3.52	10	--	6MD	
CC2	FRONT - SP-10	2.85		3.54	9	5mm	4MD	DITTO
	BACK - SP-10	2.85		3.52	10	--	4MD	
CD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		3.54	9	5mm	2F	HEAVY RUST TOP OF WELD AND BLSTR ADJ TO
	BACK - 7" DISC-36 GRIT A.O.	1.9		3.52	10	--	2F	
CD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		3.54	8	5mm	4M	BLISTERS AROUND WELD
	BACK - 7" DISC-36 GRIT A.O.	1.9		3.52	10	--	2F	
CT1	FRONT - 5" VELCRO PAD-A COARSE	1.6		3.54	9	6mm	6F	BLISTERS ADJACENT TO WELD
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		3.52	10	--	10	
CT2	FRONT - 5" VELCRO PAD-A COARSE	1.6		3.54	8	5mm	2M	BLISTERS AROUND WELD
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		3.52	10	--	2F	

*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.10
(ORIGINAL SURFACE PREP SSPC-SP-7)
(WELD BEAD)

TEST: ASTM B 117 SALT SPRAY TESTING

LOC: TRUESDAIL LABORATORIES, INC. TUSTIN CA

TIME: 2000 HOURS

PAN ID	SURFACE PREPARATION	PRO-FILE**	PAINT SYS.	TOT. DFT**	RUST GRADE	SCRIBE UNDER CUT	BLISTER GRADE	COMMENTS
SC1	FRONT - SP-10	2.85	INSULATED SPACES MARE IS. EPOXY F-150 3 MDFT	3.54	8	5mm	4VF	WELD OK NO BLISTERS
	BACK - SP-10	2.85		3.52	10	--	2F	*
SC2	FRONT - SP-10	2.85		3.54	9	5mm	4F	
	BACK - SP-10	2.85		3.52	10	--	2F	*
SD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		3.54	9	6mm	10	TWO RUST FAILURES AND DELAMINATION ON WELD
	BACK - 7" DISC-36 GRIT A.O.	1.9		3.52	10	--	8VF	*
SD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		3.54	9	5mm	10	
	BACK - 7" DISC-36 GRIT A.O.	1.9		3.52	10	--	10	
ST1	FRONT - 5" VELCRO PAD-A COARSE	1.6		3.54	9+	5mm	10	BLSTRS CONCENTRATED AROUND HT AFFECTED ZON
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		3.52	10	--	6F	*
ST2	FRONT - 5" VELCRO PAD-A COARSE	1.6		3.54	8	5mm	2F	ONE LARGE BLISTER ON SCRIBE NEAR WELD
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		3.52	10	--	4M	*

*All blisters concentrated around heat affected zone.
**Mils

TEST II EVALUATION MATRIX
TABLE 2.1.11
(ORIGINAL SURFACE PREP SSPC-SP-10)
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE

LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, N.J.

TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDER CUT	BLISTER GRADE	COMMENTS
CC1	FRONT - SP-10	2.85	INSULATED SPACES MARE IS. EPOXY F-150 3 MDFT	3.54				MISSING
	BACK - SP-10	2.85		3.52		--		
CC2	FRONT - SP-10	2.85		3.54				MISSING
	BACK - SP-10	2.85		3.52		--		
CD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		3.54	9	6mm	10	SCRIBE RUST 100%
	BACK - 7" DISC-36 GRIT A.O.	1.9		3.52	9	--	10	
CD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		3.54				MISSING
	BACK - 7" DISC-36 GRIT A.O.	1.9		3.52		--		
CT1	FRONT - 5" VELCRO PAD-A COARSE	1.6		3.54				MISSING
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		3.52		--		
CT2	FRONT - 5" VELCRO PAD-A COARSE	1.6		3.54				MISSING
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		3.52		--		

Note: Total failure after 29 months of exposure.
*Mils

TEST II EVALUATION MATRIX
TABLE 2.1.12
(ORIGINAL SURFACE PREP SSPC-SP-7)
(WELD BEAD)

TEST: ATMOSPHERIC EXPOSURE

LOC: OCEAN CITY RESEARCH CORP. OCEAN CITY, N.J.

TIME: 10 MONTHS

PAN ID	SURFACE PREPARATION	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE	SCRIBE UNDER CUT	BLISTER GRADE	COMMENTS
SC1	FRONT - SP-10	2.85	INSULATED SPACES MARE IS. EPOXY F-150 3 MDFT	3.54	10	0	10	SCRIBE RUST 100%
	BACK - SP-10	2.85		3.52	10	--		
SC2	FRONT - SP-10	2.85		3.54				MISSING
	BACK - SP-10	2.85		3.52		--		
SD1	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		3.54	9			MISSING
	BACK - 7" DISC-36 GRIT A.O.	1.9		3.52	9	--		
SD2	FRONT - FLAP WHEEL-60 GRIT A.O.	1.52		3.54				MISSING
	BACK - 7" DISC-36 GRIT A.O.	1.9		3.52		--		
ST1	FRONT - 5" VELCRO PAD-A COARSE	1.6		3.54				MISSING
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		3.52		--		
ST2	FRONT - 5" VELCRO PAD-A COARSE	1.6		3.54				MISSING
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		3.52		--		

Note: After 29 months exposure SP-10 panels rust grade 7, scribe cut-back 0, blister grade 10 with some rust on weld; general condition fair.
*Mils

TEST III EVALUATION
TABLE 3.1A
(WELD BEAD)

TEST PRESSURE IMMERSION

LOC STEEL STRUCTURE PAINTING

TIME 14, 28, 42 DAYS, PRESSURE. 50 psi

TEMP 110 F

PAN ID	SURFACE	PRO-FILE*	PAINT SYS	TOT DFT*	RUST GRADE 14	RUST GRADE 28	RUST GRADE 42	BLISTER GRADE 14	BLISTER GRADE 28	BLISTER GRADE 42	SCRIBE UNDER CUT	COMMENT 14 DAYS	COMMENT 28 DAYS	COMMENT 42 DAYS
SC1	FRONT - 4" CLEAN 'N STRIP	2.2	TANKS AND WET	8 03	10	10	10	10	6VF	4-6F	0	SCRIBE RUST 50%	SCRIBE RUST 75%	SAME
	BACK - 4" CLEAN 'N STRIP	2 2	SPACES	7.87	10	10	9	10	10	6F	--			BLISTER HEAT ZONE
SC2	FRONT - 4" CLEAN 'N STRIP	2 2	2 COATS EPOXY	8.03	10	10	10	10	4F	2-4M	0	SCRIBE RUST 70%	SCRIBE RUST 100%	SAME
	BACK - 4" CLEAN 'N STRIP	2.2	FP-034 4 MDFT	7.87	10	10	10	10	10	8VF	--			BLISTER HEAT ZONE
SD1	FRONT - FLAP WHEEL-60 GRIT A O	1.84	FP-052	8 03	10	10	10	10	4F	2-6M	0	SCRIBE RUST 75%	SCRIBE RUST 90%	SCRIBE RUST 100%
	BACK - 7" DISC-36 GRIT A.O.	2.0	4 MDFT	7.87	10	10	10	10	10	8VF	--			BLISTER HEAT ZONE
SD2	FRONT - FLAP WHEEL-60 GRIT A O.	1.84		8.03	10	10	10	10	4MF	2-4M	0	SCRIBE RUST 55%	SCRIBE RUST 100%	SAME
	BACK - 7" DISC-36 GRIT A.O.	2.0		7.87	10	10	10	10	10	10	--			
ST1	FRONT - 5" VELCRO PAD-A COARSE	1 7		8.03	10	10	10	10	4VF	2-4M	0	SCRIBE RUST 60%	SCRIBE RUST 100%	SAME
	BACK -7" DISC-36 GRIT ZIRCONIUM	2 1		7 87	10	10	10	10	10	8F	--			BLISTER HEAT ZONE
ST2	FRONT - 5" VELCRO PAD-A COARSE	1 7		8 03	10	10	10	10	4F	2-4M	0	SCRIBE RUST 100%	SAME	SAME
	BACK -7" DISC-36 GRIT ZIRCONIUM	2.1		7.87	10	10	10	10	10	8VF	--			BLISTER HEAT ZONE

Note: All blisters adjacent/surrounding heat affected zone
*Mils

TEST III EVALUATION
TABLE 3.1B
(WELD BEAD)

TEST. PRESSURE IMMERSION

LOC: STEEL STRUCTURE PAINTING

TIME. 14, 28, 42 DAYS, PRESSURE: 50 psi

TEMP. 110 F

PAN ID	SURFACE	PRO-FILE*	PAINT SYS.	TOT. DFT*	RUST GRADE 14	RUST GRADE 28	RUST GRADE 42	BLISTER GRADE 14	BLISTER GRADE 28	BLISTER GRADE 42	SCRIBE UNDER CUT	COMMENT 14 DAYS	COMMENT 28 DAYS	COMMENT 42 DAYS
CC1	FRONT - SP-10	2.85	TANKS WET SPACES	8.03	10	10	10	10	10	10	0	SCRIBE RUST 100%	SAME	SAME
	BACK - SP-10	2.85	2 COATS	7.87	10	10	10	10	10	10	--			
CC2	FRONT - SP-10	2.85		8.03	10	10	10	10	6VF	6VF	0	SCRIBE RUST 100%	SAME	SAME
	BACK - SP-10	2.85	EPOXY FP-034 4 MDFT	7.87	10	10	10	10	10	8VF	--			
CD1	FRONT - FLAP WHEEL-60 GRIT A O.	1.52		8.03	10	10	10	10	4MF	2-4M	0	SCRIBE RUST 65%	SAME	SAME, RUST SPT WELD
	BACK - 7" DISC-36 GRIT A.O.	1.9	FP-052 4 MDFT	7.87	10	10	10	10	10	2VF	--			
CD2	FRONT - FLAP WHEEL-60 GRIT A O.	1.52		8.03	10	10	10	10	4MF	2-4M	0	SCRIBE RUST 100%	SAME	SAME
	BACK - 7" DISC-36 GRIT A.O.	1.9		7.87	10	10	10	10	10	6VF	--			
CT1	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	10	10	10	6F	2-4M	0	SCRIBE RUST 100%	SAME	SAME
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	10	10	10	10	10	--			
CT2	FRONT - 5" VELCRO PAD-A COARSE	1.6		8.03	10	10	10	10	4F	2-4M	0	SCRIBE RUST 95%	SAME	SCRIBE RUST 100%
	BACK -7" DISC-36 GRIT ZIRCONIUM	1.9		7.87	10	10	10	10	10	10	--			

Note: All blisters adjacent/surrounding heat affected zone
*Mils

ADDENDUM C

CATALOGUE OF SMALL TOOLS FOR SURFACE PREPARATION AND SUPPORT EQUIPMENT FOR BLASTERS AND PAINTERS

CHAPTER TWO

(Update)

1.0 INTRODUCTION

Two of the most significant and widely used group of products developed since the 1977 publication of the "Small Tools Catalogue" are: (1) additional attachments and heads for rotary peening/scarifiers equipment, both hand-held and deck machines, and (2) "Scotch-Brite" "Clean 'N Strip" wheels and discs. The use of vacuum shroud (dust collector) attachments for these and other hand operated power tools are also becoming more popular because of increasing regulatory constraints on open abrasive blasting.

A review of both research and industry publications indicates significant current activity and increased acceptance of power tool cleaning as an effective method of surface preparation for coating application. Specialized applications such as scarifies to remove old coatings and preparing concrete for coating in the nuclear industry, and the attachment of vacuum devices to contain dust and paint debris, which may be hazardous, are examples of newer applications for these tools.

Researchers have evaluated power tool cleaned surfaces with respect to paint performance and have found many coatings perform surprisingly well in some of the harshest field environments.

The recognition of power tool cleaning as an acceptable method to prepare surfaces for painting is demonstrated by the issuance of NAVSEA T9040-AA-HB-O10/FMS, "Handbook Shipboard Facilities Maintenance" and Steel Structures Painting Council's (SSPC) Surface Preparation Specification 11-87T, "Power Tool Cleaning to Bare Metal." The SSPC document covers the requirements for power tool cleaning to produce a bare metal surface and to retain or produce a surface profile.

2.0 ENVIRONMENTAL PERSPECTIVE

Newly enacted and proposed clean-air, waste reduction/disposal and worker safety and health regulations will result in a severe reduction in the use of open-abrasive blasting for preparing surfaces for painting. This will necessitate the increased use of recyclable abrasives, dust containment and vacuum shrouded power tools. Regulatory pressures have already resulted in increased application of these alternatives in bridge, municipal structures and industrial facilities painting operations.

Fortunately, the extended use of lead pigmented paints on U.S. built commercial ships was primarily discontinued years ago. However, the use of zinc chromate primers continued, particularly in Naval vessel construction. Waste containing these materials is often classified as hazardous. Hazardous waste must be contained, classified, controlled and treated before disposal. Additionally, special worker health and safety regulations must be implemented. Repair yards must be cautios to identify what materials are being removed, since many of the older ships, including navy vessels, may have been maintained by foreign yards and unspecified materials procured and used. These incentives, as well as the necessity of protecting outfitting items sensitive to dust, will further increase the use of vacuum shrouded power tools. Such attachments are available on most power tools (Cleco, Desco, Dynabrade, etc.) including needle guns (Desco, Marindus, Pentek, etc.). Rotary peening/inpact machines with dust collectors are also available. Cleaning Rates of 400 sq. fi.lhr. in removing lead contaminated mill scale from uncoated floors of petroleum storage tanks has been reported for this equipment. In removing lead or chromium-containing paint that is classified as hazardous, power tools have the advantage of reducing the volume of generated waste ten-fold or better when compared to abrasive blasting. The treatment and disposal of such hazardous waste is most often the costliest step of the process.

3.0 POWER TOOL CLEANING TO BARE METAL

The Steel Structures Painting Council's SSPC-SP-11-87T, "Power Tool Cleaning to Bare Metal," a consensus specification, documents the requirements for power tool cleaning to produce a bare metal surface and to retain or produce a surface profile. It requires that all common contaminants except salts must be removed. Slight residues of rust or paint are permitted in the pit bottoms of pitted surfaces. It also specifies that the surface profile retained or produced must be acceptable for the paint system to be applied. A minimum profile of 1 mil (25 microns) is required.

This specification also notes that because of the shape and configuration of the power tools and the structure to be cleaned, some areas may be inaccessible for cleaning. Examples include fastener heads, inside corners, and limited clearance areas. For these areas, an alternate method, which may produce a different degree of cleanliness, maybe required. The alternate method to be used and the degree of cleanliness should be agreed upon before work is initiated.

This specification provides a comprehensive and practical standard to specify and characterize the surface that can be obtained with power tool cleaning. A two step process requiring use of multiple power tools may be required to obtain the surface condition specified.

The first step in the process is the removal of the specific contaminants present. The method and tools to be used are dependent upon structure configuration material to be removed and the original surface condition. The cleaning media most often used include non-woven abrasive wheels and discs, coated abrasive discs and flap wheels, wire wheels, rotary peening flaps, hammers, cutters, abrasive wheels, and needle guns. If the original surface was prepared by abrasive blasting to SSPC-SP-1O Near-white, sufficient profile most likely will remain after cleaning to meet the specification requirement. Previous research indicates that power tool cleaning to repair burn damage resulting from on-block weIding of outfitting materials meets the minimum profile requirements.

If sufficient profile remains, the undamaged coating can be feather edged by disc sanding, and painting can proceed without further surface preparation. If the anchor pattern remaining after cleaning is not sufficient, the use of an impact tool such as a rotary-opener or needle gun will be required to create the necessary profile.

Table 1 provides data on the profile reduction resulting from the power tool repair of weld damaged surfaces for repainting. Data was derived from the tests described in Addendum A, Test Design, of this report.

Table 1. Profile Reduction Data

Tool	Panel Front	Panel Back
Wire Brush	2.3* 3.1**	2.9* 3.1**
Clean 'N Strip disc	1.4* 3.1**	2.3* 3.1**
Flap Wheel/60 Grit Aluminum Oxide	1.7* 3.1**	
36 Grit Disc Aluminum Oxide		1.9* 3.1**
'Velcro' Pad-A Coarse	1.6* 3.1**	
36 Grit Disc Zirconium Oxide		2.0* 3.1**

*Residual profile after power tool cleaning
**Nominal abrasive blast profile before coating (steel grit)

Note: Panel fronts had a greater reduction in profile because of concentrated cleaning around weld.

4.0 TOOLS AND ACCESSORIES

As previously stated, the availability of "Clean 'N Strip" discs and unitized wheels, RotoPeen flap wheels and dust collection systems for many of the power tools are the most significant developments in surface conditioning since the publication of the Small Tool Catalogue in 1977. There are many specialized applications for power tool surface preparation and accessories have been developed for these uses. Developments and their uses in ship construction and maintenance are discussed in the following paragraphs.

4.1 "Clean 'N Strip" Disc and Unitized Wheels

These surface conditioning products are marketed by the Building and Service division of 3M and are patented under the Trademark "Scotch-Brite." These products, as illustrated in Figure 1 and 2, have a unique design consisting of a combination of synthetic fibers and abrasive particles bonded together to form a resilient open-web material. This construction provides a spring-like action to increase conformance to irregularly shaped surfaces.

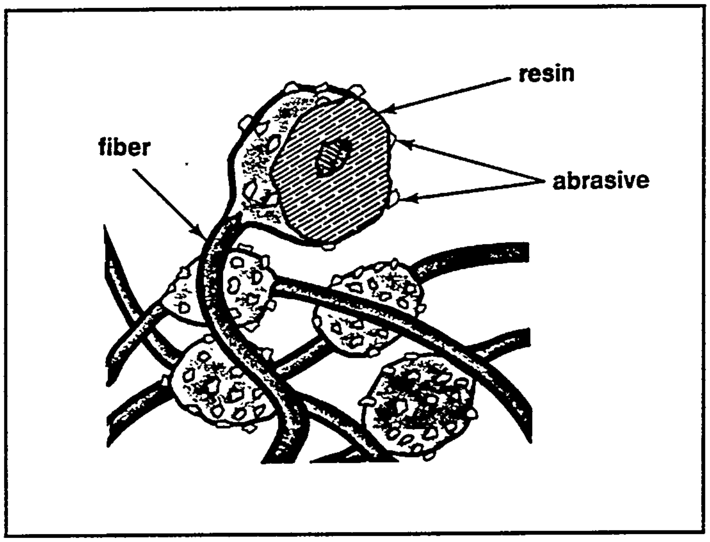


Figure 1. Clean 'N Strip Design

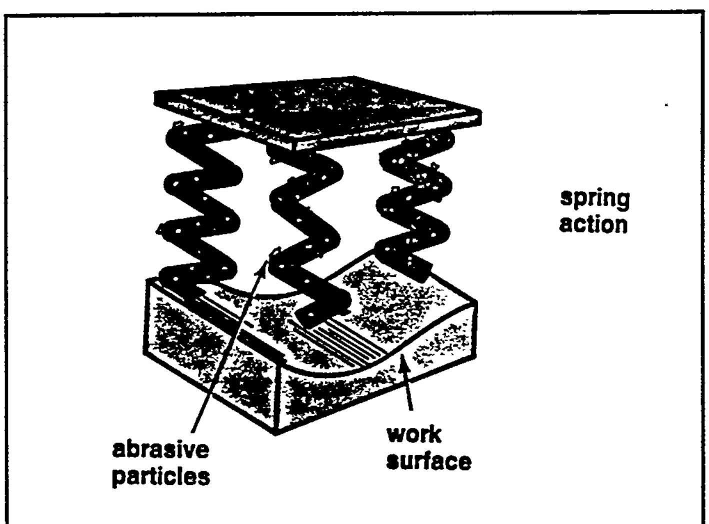


Figure 2. Resilent Features

The manufacturer states that the design offers the following performance advantages:

- Cool running to avoid warping or discoloring the part
- Conform ability to follow contours
- Controlled abrasive action to reduce undercutting or gouging of valuable parts
- Non-metallic construction which eliminates loose-flying wires or impingement of metal and other contaminants into the surface, as with wire wheels
- Consistent results because fresh abrasive is continually exposed to the work surface
- Resistance to loading from surface contaminants
- Smooth running wheels for greater worker comfort and productivity

These materials are marketed in many different configurations for a variety of applications and for use with multiple tools such as hand-pads, firm unitized wheels (power hand tools or bench motors), pads for angle grinders or sanders, cup-wheels and discs mounted back-to-back on a straight grinder or bench motors to clean pipe.

The “Clean ‘N Strip” unitized wheels are laminated discs of the same material compressed into a denser construction. They are more rigid and less coforming than discs. They are designed for heavier duty applications and will remove more material at a faster rate. (Product information is listed in Figure 3.) The wheels effectively remove damaged coatings, weld smoke and corrosion products in preparing surfaces for repainting. Sufficient profile normally remains to repaint without additional preparation if the surfaces have been previously abrasive blasted.

Product Information – Clean 'N Strip Discs

Color	Mineral	Grade
Black	Silicon Carbide (Type S)	Extra Coarse

Popular Sizes

Diameter (Inches)	Maximum Operating Speed (RPM)
2	12,000
3	8,500
4	6,000
5	5,000
6	4,000
7	3,300
8	3,000
10	2,300
12	1,900
13	1,700
14	1,600
15	1,500
16	1,300

This listing represents popular sizes – other diameters are available.

Centerholes: Various sizes, customer specified

Hardware: Use the 3M Mandrel No. 933 or 934. Can be directly mounted to production equipment. Refer to Scotch-Brite® Surface Conditionina Price Book, C-189.

Product Information – Clean 'N Strip Unitized Wheels

Color	Density	Mineral Type	Grade
Black	7 (Hard)	Silicon Carbide (Type S)	Extra Coar

Popular Sizes

Diameter x Width x Centerhole (Inches)			Maximum Operating Speed (RPM)
1	1	3/16	20,000
2	1/4	1/4	16,000. *18,000
2	1/2	1/4	16,000. *18,000
2-1/2	1/4	1/4	14,000
2-1/2	1/2	1/4	14,000
2-1/2	1	1/4	14,000
3	1/4	1/4	12,000. *18,000
3	1/2	1/4	12,000
3	1	1/4	12,000
4	1/2	1/4	8,500
4	3/4	1/4	8,500
4	1	1/4	8,500
6	1/2	1/2	4,800
6	1	1/4	4,800
8	1/2	1/2	3,800
8	1	1/2	3,800

This listing represents popular sizes available. Many other diameters and widths are available to meet your production requirements.

* Certified to run at higher RPMs when used with proper 3M Brand Mandrel 940 and 941.

Centerhole: Centerholes can be specified match tooling requirements.

Hardware: Use with 3M Brand Mandrel: No. 931, 932, 933, 934, 936, 937, 940 or 941. Refer to Scotch-Brite® Surface Conditioning Price Book C-18[illegible]

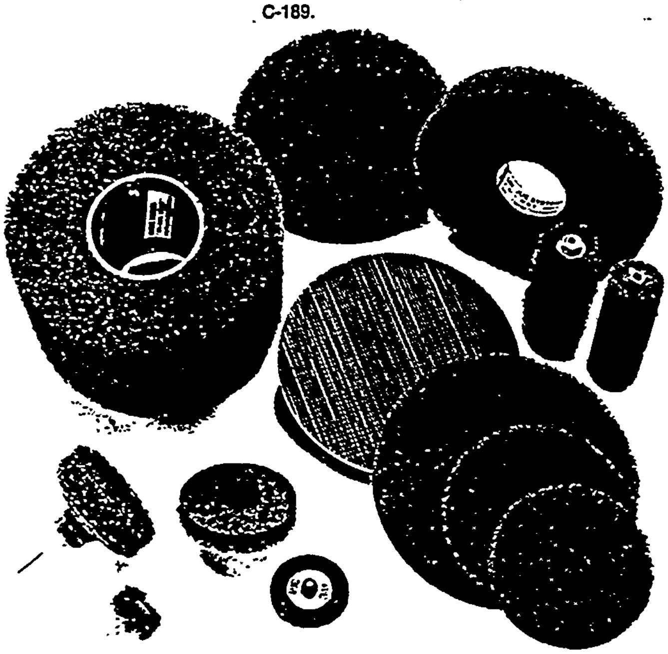


Figure 3. "Clean 'N Strip" Product Information

The unit cost of the "Clean 'N Strip" items is higher than abrasive bonded material and can wear excessively if not used properly. Their unique properties make them a valued choice in some operations, especially where good surface conformance and limited substrate damage is desired. In other operations where these performance characteristics are not essential, an evaluation of their cost effectiveness with other alternatives (such as bonded abrasive discs or Flap wheels) is recommended.

4.2 RotoPeen

RotoPeen, a product of 3M's "Scotch-Brite" surface conditioning line, which was referenced in the original "Small Tools Catalogue," has found increased usage. The publication of the NAVSEA's Shipboard Facilities Maintenance Handbook and SSPC-SP-11-87T has done much to implant its use. It is a rotary impact flap assembly consisting of a flexible loop construction with carbide spheres bonded to the peening surfaces of each of the metal supports fastened to the loop. (See Figure 4). It can remove heavy corrosion, paint films and mill scale and imparts the necessary profile required by SSPC-SP-11-87T. The assembly is designed to be used with either hand-held or mechanized floor equipment.

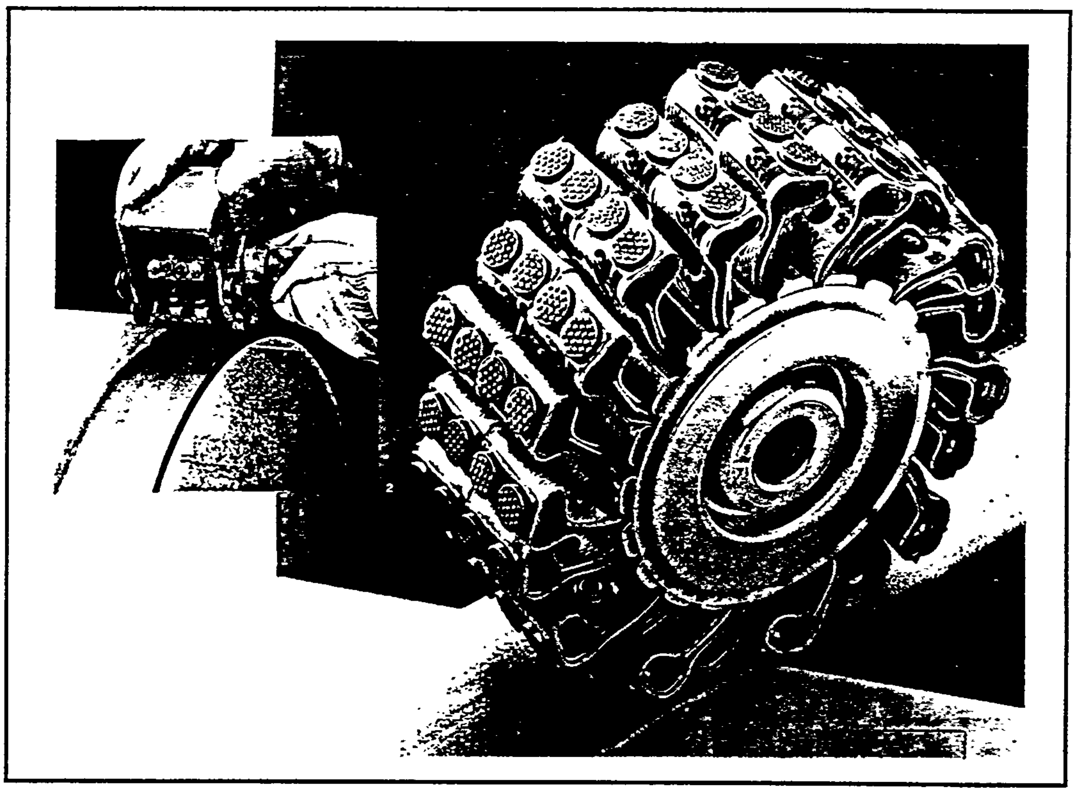


Figure 4. Rotary Impact Flap Assembly

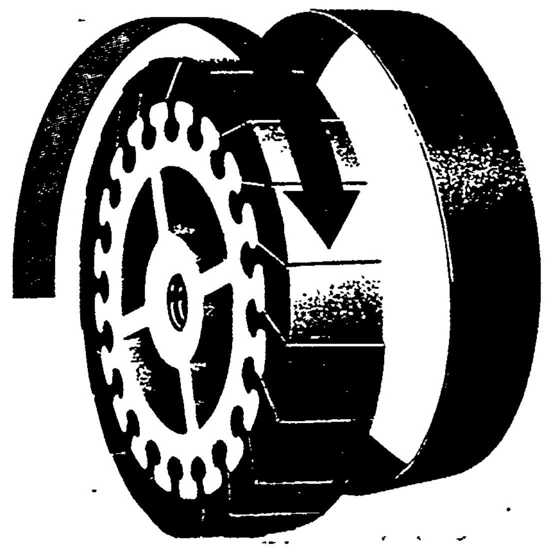
The hand-held equipment can weigh as little as 4.5 lbs and can clean within 0.25 inches of a perpendicular surface. The equipment manufacturer's installation and operation instructions should be carefully followed or damage to the equipment or the substrate to be cleaned may occur.

4.3 "Nu-Matic" Wheels

Nu-matic wheels are air inflated backups for sleeve/belt configured bonded abrasives. Their major advantage is close conformance to the work surface.

Nu-matic Grinders Incorporated has also developed a new wheel design, called "Flexcore." (See Figure 5.) Individual rubber flexures are inserted into slots in the wheel. These individual rubber segments flex outward against the bonded abrasive band due to centrifugal force during operation. This exerts a positive gripping action on the band to secure it in place.

- Expands as it rotates
- Extruded aluminum core won't wear out
- User replaceable rubber flexers
- Put more abrasive on the work piece
- Work on flats or contours
- Lower finishing costs
- Suitable for portable tool or fixed spindle applications



Specifications

Diameter	Width	Minimum Spindle Hole	Maximum Spindle Hole	Number of Flexers	Recommended RPM
1"	1", 2", 3", 4"	1/4"	3/8"	8	22,000
1½"	1", 2", 3", 4"	1/4"	3/8"	8	17,000
2"	1", 2", 3", 4"	1/4"	5/8"	16	12,000
3"	1", 2", 3", 4"	3/8"	3/4"	16	9,000
4"	1", 2", 3", 4"	3/8"	5/8"	16	6,000
5"	1", 2", 3", 4"	1/2"	3/4"	20	6,000

Figure 5. Flexcore Sanding Wheels

4.4 Descalers

There are many types and configurations of descalers. Their material removal capability depends upon impact energy, which may be applied by needles, hammers or flaps cutters. Needle guns are the most commonly used tools of this type in the shipyard. Descaling welds is the primary application. They can be fitted with different diameter needles depending upon the material to be removed. 0.2mm diameter needles are recommended for paint removal and the development of a profile for repainting.

Pneumatic scrabblers, which hammer the surface to remove residues and coatings, have been equipped with extensions to enable the operator to reach places where access is difficult.

Hand held rotary descalers are also available in various sizes and weights, the lightest being 4.5 lbs. Some of the heavier models are equipped with counter balance devices to make their operation less tiring for the operator when used on vertical surfaces. Figure 6 provides typical physical and operating data for a 4.5 lb. device.

Rotary Descaler; Hand Operated	
Air Supply:	90 psig. At 18 cfm
Air Motor:	0.5 hp at 1725 rpm min. Under load, 42 in-lbs stall torque
Air Hose:	3/8" ID
Weight:	4.5 lbs
Scaling Heads:	hammer cutters 2" wide heavy duty roto-peen flaps abrasive wheels
Scaling Rates:	Paint:.65-150 sq ft/hr Rust: 30-80 sq ft/hr

Figure 6. Rotary Scaler Data

There are a wide variety of designs of machine rotary descalers for decks or flat surfaces. (See Figure 7.) They can be used on numerous substrates and are designed to operate different devices such as flaps, hammers, cutters, and abrasive wheels. They can use a wide range of power sources, including electricity, air, gas, and water.

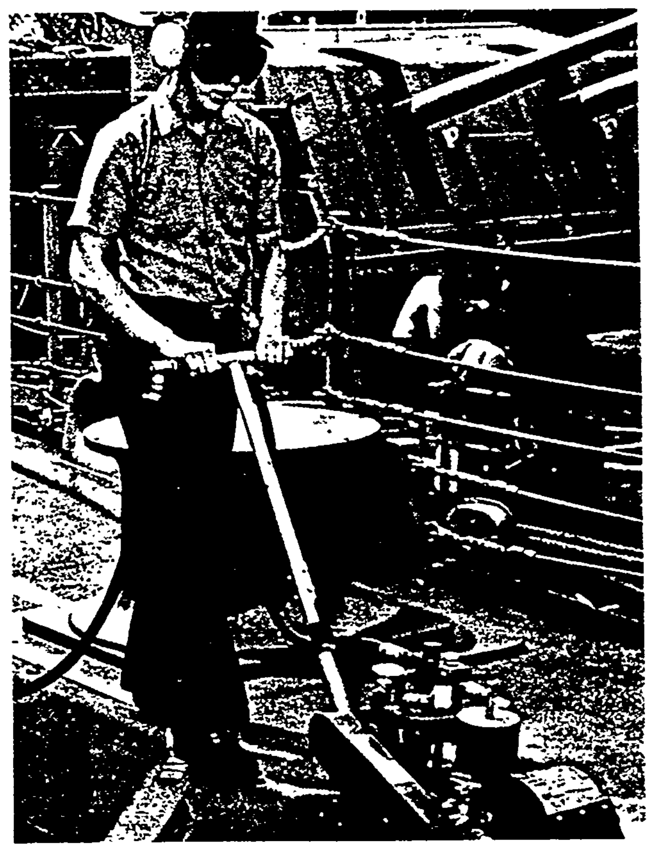


Figure 7. Descaler for Decks

4.5 Miscellaneous Power Tools

Many unique hand operated abrasive power tools are available for specialized operations. Some, when fitted with proper abrasive attachments, may be utilized in surface preparation for painting. Examples are an abrasive belt machine with a wide variety of contact arms and configurations, orbital sanders, cup polishers, and reciprocating files. Dynabrade, Inc. is a source for many of these devices.

4.6 Vacuum Systems

Accessory systems have been developed for use with power tools to reduce airborne contaminants in the removal of coatings containing hazardous materials. Companies that developed such systems include DESCO Manufacturing., Pentek, and Unique Systems. These systems are based upon vacuum recovery shrouds and specially designed attachments to conform to inside or outside corners and odd geometric shapes.

A power tool with a vacuum shroud is depicted in Figure 8, and a shrouded needle gun with special attachments and the integrated vacuum recovery system is depicted in Figure 9. Coating removal rates of 25 sq.ft./hr. from fuel tanks have been documented for this system. The remaining non-toxic mill scale was removed by abrasive blasting.

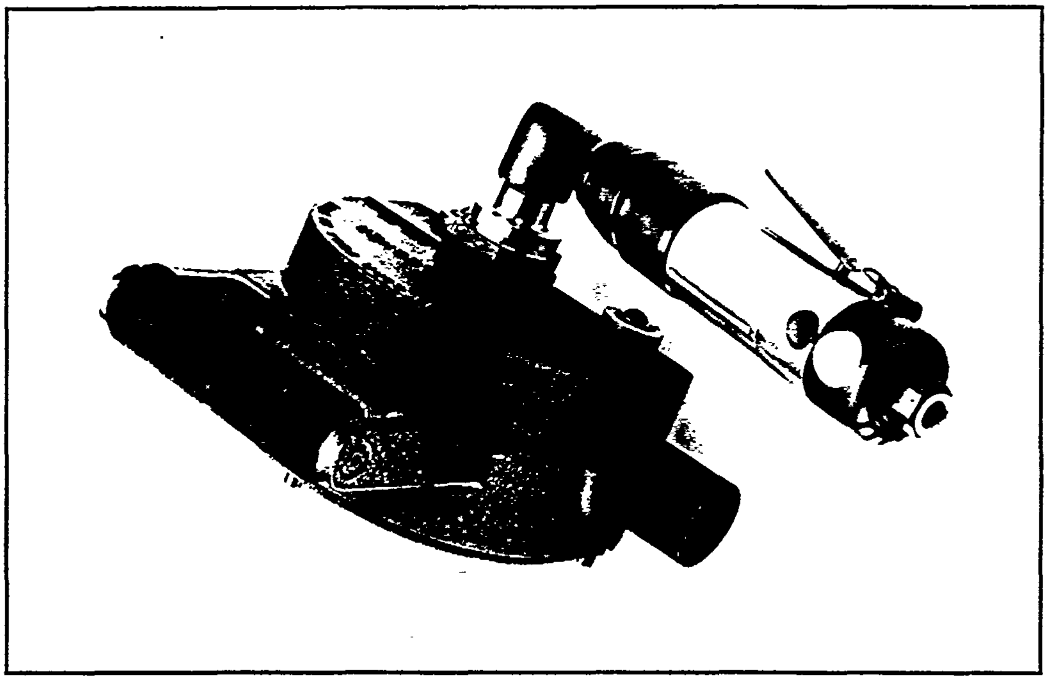


Figure 8. Power Tool With Vacuum Attachment

Figure 9. Pentek's Needle Gun Vacuum System

4.7 Operation

NAVSEA T9040-AA-HBK-010/FMS Handbook, Shipyard Facilities and Maintenance, is a valuable resource for information on the use of power tools for preparing surfaces for painting. Unique Systems Co. also provides a catalogue that augments the NAVSEA document with detailed guidelines for tool selection based on substrate and materials to be removed. Equipment manuals and operating instructions are available from the equipment suppliers. Understanding and complying with these instructions are essential for efficient and safe operation of the tools and accessories. Improper operation may result in excessive wear, damage to the equipment or substrate to be cleaned, and possible personal injury.

A good, well-lubricated air supply is essential for the efficient, trouble-free operation of power tools. Chapter 2, Page 3-2, of the original Small Tool Catalogue should be referenced for the design of such an air supply.

5.0 SUPPLIER AND PRODUCT LISTS

5.1 SUPPLIERS LIST

AAM-RO Corp. (AMS Division)
2340 W. Wabansia Avenue
Chicago, IL 60647
Mr. Bob Carey (312) 276-3646

Alpheus Cleaning Technologies Corp.
9105 Milliken Avenue
Rancho Cucamonga, CA 91730
(714) 944-0055

ASB Industries, Inc.
1031 Lambert Street
Barberton, OH 44203
(216) 753-8458 .

Capital Industrial Supply Co, Inc.
9509 Titan Park Circle
Littleton, CO 80125
(303) 791-1014

Cleco Portable Air Tools
Industrial Tool Division
(Division of Dresser Industries)
Glenn Hebert (713) 462-4521

Clemtex, Inc.
248 McCarty Drive
Houston, TX 77220-5214
(713) 672-8251

DESCO Mfg. Co.
5325 Cleveland St.
Suite 304
Virginia Beach, VA 23462

Dynabrade, Inc.
72 East Niagara Street
Tonawanda, NY 14150
(716) 694-4600

EDCO-Equipment Development Co., Inc.
100 Thomas-Johnson Drive
Frederick, MD 21701

F. W. Gartner Company
3805 Lamar Avenue
Houston, TX 77251

3M Building Service and Cleaning
Products Division
Building 223-65-03
St. Paul, MN 55144-1000

Marindus Company
P. O. Box 663
Englewood, NJ 07631
(201) 567-8383

MDC Industries, Inc.
Collins & Willard Streets
Philadelphia, PA 19134-3299
(215) 426-5925

Nu-Matic Grinders, Inc.
19870 St. Clair Avenue
Euclid, OH 44117
Linda Lescavac, (216)531-9135

Pentek
1026 4th Avenue
Coraopolis, PA 15108
(412) 262-0775

Pauli & Grifiin Company
907 Cotting Lane
Vacaville, CA 95688
(707) 447-7000

Roto-Scraper
P.O. Box 54
Idyllwild, CA 9234
Dora Pillman, (714) 659-4635

Southwest Abrasive & Equipment Co.
2675 Perth
DalIs, TX 75220

Sullair Air Tools
US 20 & Hitchcock Road
Michigan City, IN 46360

Trelawny Pneumatic Tools
Paoli Technology Center
19 East Avenue
Paoli, PA 19301
(215)251-1047

Vacuum Engineering Corp.
3374 West Hopkins Street
Milwaukee, WI 53216

J. C. Whitney Co.
1917-19 Archer Avenue
P.O. BOX 8410
Chicago, IL 60680
(312)431-6102

Throw-Away Tools

Central Pneumatic
Angle Die Grinder 20,000 rpm
$40.00
Harbor Freight Salvage Co.
1-800-423-2567

Central Pneumatic
7“ Air Sander 4,500 rpm
$67.00
J. C. Whitney Co.
(312)431-5102

5.2 PRODUCTS/SUPPLIERS

Abrasive Blast Machines

Aam-RO Corp.
  Empire “Blast ‘n’ Vac”
  Vacu-Blast

Clemco Industries
Clemtex, Inc.
Complete Abrasive Blasting Systems
EDCO-Equipment Development Co, Inc.
LTC International
MDC Industries
Paul-Griffi
Sullair Air Tools
Southwest Abrasive Equipment Co.
Vacuum Engineering

Carbon Dioxide Blasting

Alpheus Cleaning Technology Corp.

Abrasive Wheels/Disc

3M

Needle Gunds

Clemtex, Inc.
DESCO Mfg. Co., Inc.
Dynabrade, Inc.
EDCO-Equipment Development Co, Inc.
Ingersoll-Rand Co.
Marindus Co., Inc. (Van Arx)
Pentek
Trelawny

Power Tools/Accessories

Cleco (Division of Dresser Industries)
DESCO Mfg. Co., inc.
Dynabrade, Inc.

*Harbor Freight Salvage, Co.
Ingrersoll-Rand Co.
Marindus Co., Inc.
MDC Industries, Inc.
Stanley
Weiler
*J.C. Whitney & Co.

*Priced economically; may or may not be designed for heavy work.

<u>Scaler/Scarifier (Portable/Deck)</u>

Aam-Ro Corp.
DESCO Mfg. Co., Inc.
Dynabrade, Inc.
EDCO-Equipment Development Co., Inc.
Marindus Co., Inc.
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